МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ОДЕСЬКИЙ НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ
імені І. І. МЕЧНИКОВА
ФАКУЛЬТЕТ РОМАНО-ГЕРМАНСЬКОЇ ФІЛОЛОГІЇ
КАФЕДРА ІНОЗЕМНИХ МОВ ПРОФЕСІЙНОГО СПРЯМУВАННЯ

ENGLISH FOR STUDENTS OF PHYSICS AND ASTRONOMY

(PART 1. MECHANICS, THERMODYNAMICS AND MOLECULAR PHYSICS)

МЕТОДИЧНІ ВКАЗІВКИ

до практичних занять
з навчальної дисципліни «Іноземна мова
(за професійним спрямуванням)»
для здобувачів першого (бакалаврського) рівня вищої освіти
спеціальності 104 «Фізика та астрономія»

ОДЕСА
ОЛДІ+
2024

УДК 811.111’243’276.6:[531/534+536+539.19](072)
Е56

Укладач:
Г. П. Кузнєцова, старший викладач кафедри іноземних мов професійного спрямування ОНУ імені І. І. Мечникова.

Рецензенти:
О. М. Набока, к. філол. н., доц. кафедри іноземних мов професійного спрямування ОНУ імені І. І. Мечникова;
Г. В. Ткаченко, к. філол. н., доц. кафедри лексикології та стилістики англійської мови ОНУ імені І. І. Мечникова.

Рекомендовано до друку вченою радою
факультету романо-германської філології ОНУ імені І. І. Мечникова.
Протокол № 11 від 27 червня 2024 р.

Е56 **ENGLISH** FOR STUDENTS OF PHYSICS AND ASTRONOMY. (PART 1. MECHANICS, THERMODYNAMICS AND MOLECULAR PHYSICS) : метод. вказівки до практичних занять з навчальної дисципліни «Іноземна мова (за професійним спрямуванням)» для здобувачів першого (бакалаврського) рівня вищої освіти спеціальності 104 «Фізика та астрономія» / уклад. Г. П. Кузнєцова. – Одеса : Олді+, 2024. – 94 с.

Методичні вказівки до практичних занять містять тексти за спеціальністю, списки слів та термінів, вправи для виконання практичних завдань, теми для обговорювання.

УДК 811.111’243’276.6:[531/534+536+539.19](072)

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ВСТУП

Методичні вказівки «**ENGLISH FOR STUDENTS OF PHYSICS AND ASTRONOMY. (PART 1. MECHANICS, THERMODYNAMICS AND MOLECULAR PHYSICS)**» розроблені до практичних занять з навчальної дисципліни «Іноземна мова (за професійним спрямуванням)» для здобувачів вищої освіти першого (бакалаврського) рівня за спеціальністю 104 - «Фізика та астрономія». Зміст методичних вказівок відповідає робочій програмі навчальної дисципліни. Матеріал рекомендовано використовувати у першому та другому семестрах першого курсу.

Методичні вказівки містять 10 розділів за спеціальністю, в кожному є автентичний текст за спеціальністю, питання до тексту, списки слів та термінів для удосконалення фахової лексики, лексичні вправи та вправи на переклад, а також завдання для самостійного пошуку інформації в Інтернеті.

Методичні вказівки надають можливості для обговорення англійською мовою важливих питань з фізики з метою підвищення ефективності професійного спілкування та формування у студентів комплексу знань, умінь, необхідних для подальшої професійної діяльності.

Unit 1.

I. Read and translate the text. Learn the new vocabulary

Physics – the most fundamental physical science

Physics, the most fundamental physical science, is concerned with the fundamental principles of the Universe. It is the foundation upon which the other sciences—astronomy, biology, chemistry, and geology—are based. It is also the basis of a large number of engineering applications. The beauty of physics lies in the simplicity of its fundamental principles and in the manner in which just a small number of concepts and models can alter and expand our view of the world around us. The study of physics can be divided into six main areas:

1. classical mechanics, concerning the motion of objects that are large relative to atoms and move at speeds much slower than the speed of light

2. relativity, a theory describing objects moving at any speed, even speeds approaching the speed of light

3. thermodynamics, dealing with heat, work, temperature, and the statistical behavior of systems with large numbers of particles

4. electromagnetism, concerning electricity, magnetism, and electromagnetic fields

5. optics, the study of the behavior of light and its interaction with materials

6. quantum mechanics, a collection of theories connecting the behavior of matter at the submicroscopic level to macroscopic observations.

The disciplines of mechanics and electromagnetism are basic to all other branches of classical physics (developed before 1900) and modern physics (c. 1900–present). Many principles and models used to understand mechanical systems retain

their importance in the theories of other areas of physics and can later be used to describe many natural phenomena. Therefore, classical mechanics is of vital importance to students from all disciplines.

Like all other sciences, physics is based on experimental observations and quantitative measurements. The main objectives of physics are to identify a limited number of fundamental laws that govern natural phenomena and use them to develop theories that can predict the results of future experiments. The fundamental laws used in developing theories are expressed in the language of mathematics, the tool that provides a bridge between theory and experiment. When there is a discrepancy between the prediction of a theory and experimental results, new or modified theories must be formulated to remove the discrepancy. Many times a theory is satisfactory only under limited conditions; a more general theory might be satisfactory without such limitations. For example, the laws of motion discovered by Isaac Newton (1642–1727) accurately describe the motion of objects moving at normal speeds but do not apply to objects moving at speeds comparable to the speed of light. In contrast, the special theory of relativity developed later by Albert Einstein (1879–1955) gives the same results as Newton's laws at low speeds but also correctly describes the motion of objects at speeds approaching the speed of light. Hence, Einstein's special theory of relativity is a more general theory of motion than that formed from Newton's laws.

Classical physics includes the principles of classical mechanics, thermodynamics, optics, and electromagnetism developed before 1900. Important contributions to classical physics were provided by Newton, who was also one of the originators of calculus as a mathematical tool. Major developments in mechanics continued in the 18th century, but the fields of thermodynamics and electromagnetism were not developed until the latter part of the 19th century, principally because before that time the apparatus for controlled experiments in these disciplines was either too crude or unavailable.

A major revolution in physics, usually referred to as modern physics, began near the end of the 19th century. Modern physics developed mainly because many physical phenomena could not be explained by classical physics. The two most important developments in this modern era were the theories of relativity and quantum mechanics. Einstein's special theory of relativity not only correctly describes the motion of objects moving at speeds comparable to the speed of light; it also completely modifies the traditional concepts of space, time, and energy. The theory also shows that the speed of light is the upper limit of the speed of an object and that mass and energy are related. Quantum mechanics was formulated by a number of distinguished scientists to provide descriptions of physical phenomena at the atomic level. Many practical devices have been developed using the principles of quantum mechanics. Scientists continually work at improving our understanding of fundamental laws. Numerous technological advances in recent times are the result of the efforts of many scientists, engineers, and technicians, such as unmanned planetary explorations, a variety of developments and potential applications in nanotechnology, micro circuitry and high-speed computers, sophisticated imaging techniques used in scientific research and medicine, and several remarkable results in genetic engineering. The effects of such developments and discoveries on our society have indeed been great, and it is very likely that future discoveries and developments will be exciting, challenging, and of great benefit to humanity.

(From Physics for Scientists and Engineers with Modern Physics, Raymond A. Serway, John W.Jewett Jr., pp.2-3)

Vocabulary

physics [ˈfɪzɪks]	фізика
to be concerned with	*тут*. бути пов'язаним з
simplicity [sɪmˈplɪs.ɪ.ti]	простота

alter [ˈɔːltə(r)]	змінювати
expand	розширити
relativity [ˌrel.əˈtɪv.ɪ.ti]	відносність
thermodynamics [ˌθɜː.məʊ.daɪˈnæm.ɪks]	термодинаміка
electromagnetic fields	електромагнітні поля
interaction	взаємодія
natural phenomena (phenomenon – sing.)	природні явища (явище – одн.)
experimental observations	експериментальні спостереження
quantitative measurement [ˈkwɒn.tɪ.tə.tɪv ˈmeʒəmənt]	кількісне вимірювання
tool	інструмент
discrepancy [dɪˈskrep.ən.si]	невідповідність
accurately [ˈæk.jʊ.rət -li]	точно
calculus [ˈkæl.kjʊ.ləs]	обчислення
crude [kruːd]	сирий
distinguished scientists [dɪˈstɪŋ.gwɪʃt ˈsaɪən.tɪsts]	видатні вчені
quantum mechanics [ˈkwɒn.təm məˈkæn.ɪks]	квантова механіка
technological advances	технічний прогрес
micro circuitry [ˈmaɪ.krəʊ ˈsɜː.kɪ.tri]	мікросхемотехніка; мікросхеми; інтегральні схеми

Exercise 1. Answer the following questions

1. What is physics concerned with? 2. What other sciences are based on physics? 3. What does the beauty of physics lie in? 4. What areas can the study of physics be divided into? 5. What is the difference between classical physics and modern physics? 6. What is used to understand mechanical systems retain their importance in the theories of other areas of physics? 7. Why is classical mechanics of vital importance to students from all disciplines? 8. What is physics based on? 9. What are the main objectives of physics? 10. How are the fundamental laws in developing theories expressed? 11. Many times a theory is satisfactory only under limited conditions, isn't it? Give some examples. 12. What does classical physics include? 13. Who provided important contributions to classical physics? 14. Did major developments in mechanics continue in the 18th century? 15. Why did modern physics develop? 16. The two most important developments in this modern era were the theories of relativity and quantum mechanics, weren't they? 17. What does Einstein's special theory of relativity show? 18. Why was quantum mechanics formulated? 19. What can you say about recent technological advancements? 20. Will future discoveries be exciting? What do you think?

Exercise 2. Find the English equivalents in the text. Use them in your own sentences

бути зацікавленим фундаментальними принципами Всесвіту, простота його фундаментальних принципів, велика кількість інженерних застосувань, розширити наш погляд на світ, бути розділеним на, рух об'єктів, рухатися зі швидкістю, мати справу з, велика кількість частинок, що стосується чогось, низка теорій, зберігати важливість, описувати багато природних явищ, базуватися на експериментальних спостереженнях, бути вираженою мовою математики, забезпечити зв'язок між теорією та експериментом, усунути невідповідність, порівнянну з, теорія відносності, один із засновників числення, низка видатних вчених, принести велику користь людству.

Exercise 3. Match the sentences

1. In many ways, physics	a) the scientific method to test the validity of a physical theory.
2. Physics	b) through its inclusion of astronomy, perhaps the oldest.
3. A scientist	c) the mathematical study of continuous change, which provided new mathematical methods for solving physical problems.
4. Physics is one of the oldest academic disciplines and,	d) is the natural science of matter, involving the study of matter, its fundamental constituents, its motion and behavior through space and time, and the related entities of energy and force.
5. Physics intersects with.	e) in the early 20th century and onward or branches greatly influenced by early 20th century physics.
6. Advances in physics often	f) early modern Europeans used experimental and quantitative methods to discover what are now considered to be the laws of physics.
7. Physics became a separate science when	g) enable new technologies.

8. Modern physics is a branch of physics that developed	h) many interdisciplinary areas of research, such as biophysics and quantum chemistry.
9. Newton also developed calculus,	i) is a person who researches to advance knowledge in an area of the natural sciences.
10. Physicists use	j) stems from ancient Greek philosophy.

Exercise 4. Translate the following sentences into English

1. Однією з частин природознавства є фізика.

2. Завдяки досягненням фізичної науки людство має унікальні знання про структуру й поведінку найрізноманітніших об'єктів — від гігантських зір до найдрібніших частинок речовини — атомів і молекул.

3. Ці знання стали основою для створення нових технологій і приладів, які допомагають у роботі лікарям і будівельникам, мандрівникам і хліборобам, полегшують наше повсякденне життя, відкривають швидкий доступ до запасів інформації, накопичених людством, тощо.

4. Фізика має надзвичайно величезне значення в сучасному світі. Без цієї важливої науки не було б фізичних відкриттів.

5. За допомогою відкриттів в термодинаміці був створений автомобіль, а дослідження електромагнітної складової подарувало людству такий сучасний засіб зв’язку, як мобільний телефон.

6. Матерія навколо нас постійно змінюється. Деякі тіла переміщуються одне відносно одного, частина з них зіштовхуються й, можливо, руйнуються, з одних тіл утворюються інші.

7. Схід і захід сонця, сходження снігової лавини, виверження вулкана, біг коня, стрибок пантери — усе це приклади різноманітних природних явищ.

8. Фізичні явища можуть бути: механічні, електричні, магнітні, світлові, теплові, звукові.

9. Ці явища вивчаються такими розділами фізики, як: механіка, оптика, електродинаміка, термодинаміка, акустика та інші.

10. Всі ці фізичні розділи тісно пов'язані між собою та формують фізичну науку, яка вивчає явища природи.

(https: //edufuture.biz/index.php?title)

Exercise 5. Read the following interesting piece of information. Share your opinion with your classmates

Do you know that GPS works on Physics formula?

Modern applications like GPS that help us find our way in life are based on a physics formula called **$E=mc^2$**. Satellite navigation systems use geostationary satellites to precisely pinpoint locations and communicate using radio waves. This is why the theory of relativity helps with the proper functioning of GPS systems. It's interesting stuff, ladies! The astronauts who are currently living in the International Space Station experience time slowly due to their different rates of velocity and gravity. This is why they sometimes look younger than what we're used to seeing them as.

(https://medium.com/@waqasseoranking30/top-10-mind-blowing-facts-about-physics-33916b04ce36)

Speaking

- Speak about the science of physics.

- Choose an outstanding physicist. Make a report and speak in class.
- Speak about some advances in modern physics.

Unit 2.

I. Read and translate the text. Learn the new vocabulary

Classical mechanics

Using just a few equations, scientists can describe the motion of a ball flying through the air and the pull of a magnet, and forecast eclipses of the moon. The mathematical study of the motion of everyday objects and the forces that affect them is called ***classical mechanics.*** Classical mechanics is often called Newtonian mechanics because nearly the entire study builds on the work of Isaac Newton. Some mathematical laws and principles at the core of classical mechanics include the following:

- **Newton's First Law of Motion**: A body at rest will remain at rest, and a body in motion will remain in motion unless it is acted upon by an external force.
- **Newton's Second Law of Motion**: The net force acting on an object is equal to the mass of that object times its acceleration.
- **Newton's Third Law of Motion**: For every action, there is an equal and opposite reaction.
- **Newton's Law of Universal Gravitation**: The pull of gravity between two objects will be proportional to the masses of the objects and inversely proportional to the square of the distance between their centers of mass.
- **Law of Conservation of Energy**: Energy cannot be created nor destroyed, and instead changes from one form to another; for example, mechanical energy turning into heat energy.

- **Law of Conservation of Momentum**: In the absence of external forces such as friction, when objects collide, the total momentum before the collision is the same as the total momentum after the collision.
- **Bernoulli's Principle**: Within a continuous streamline of fluid flow, a fluid's hydrostatic pressure will balance in contrast to its speed and elevation.

Classical mechanics accurately describes the behavior of most "normal" objects. To be considered "normal," objects should be "larger than a molecule and smaller than a planet," close to room temperature and going at speeds significantly slower than the speed of light.

Although it is the oldest branch of physics, the term "classical mechanics" is relatively new. Soon after 1900, a series of revolutions in mathematical thinking gave birth to new fields of inquiry: **relativistic** mechanics for phenomena relating to the very fast, and **quantum** mechanics for phenomena relating to the very small.

In 1687, Newton published "Mathematical Principles of Natural Philosophy" which described how bodies move under the influence of external forces. This work unified mathematical reasoning with relatively new ideas about motion here on the Earth's surface, and the most ancient of all fields of scientific inquiry: astronomy.

The ancient civilizations of Mesopotamia, Egypt and the Indus Valley all demonstrated an understanding of the motion of the sun, moon and stars; they could even predict the dates of eclipses by the 18th century B.C. **Celestial mechanics** thusly became the study of how things move about the heavens.

Using Newton's laws, scientists could manipulate symbolic math with algebra and calculus (also co-invented by Newton) to learn about phenomena not yet observed. Classical mechanics grew throughout the 18th and 19th centuries to describe everything from optics, fluids and heat to pressure, electricity and magnetism.

(From https://www.livescience.com/47814-classical-mechanics.html#:)

Vocabulary

the pull of a magnet	сила тяжіння магніту
forecast eclipses [ɪˈklɪpsiz] of the moon	прогноз місячних затемнень
to be at the core of	бути в основі
Newton's First Law of Motion	Перший закон руху Ньютона
an external force	зовнішня сила
the net force	рівнодіюча сила; результуюча сила; чиста сила
acceleration	прискорення
the pull of gravity	гравітаційний вплив; сила тяжіння; сила гравітації
to be inversely proportional to	бути обернено пропорційним
Law of Conservation of Energy	Закон збереження енергії
Law of Conservation of Momentum	Закон збереження імпульсу
friction [ˈfrɪk.ʃən]	тертя
to collide [kəˈlaɪd]	зіткнутися
the total momentum [məˈmen.təm]	загальний імпульс
a fluid's hydrostatic pressure [ˈfluːɪdz haɪdrəʊˈstætɪk preʃə(r)]	гідростатичний тиск рідини
elevation [ˌel.ɪˈveɪ.ʃən]	висота

relativistic mechanics	релятивістська механіка
celestial mechanics [sɪˈles.ti.əl məˈkæn.ɪks]	небесна механіка
calculus [ˈkæl.kjʊ.ləs]	математичний аналіз; вища математика; обчислення

Exercise 1. Answer the following questions

1. What can scientists do using just a few equations? 2. What is called classical mechanics? 3. What is classical mechanics often called? 4. What are some mathematical laws and principles at the core of classical mechanics? Name them. 5. What does the Newton's First Law of Motion state? 6. Is the net force acting on an object equal to the mass of that object times its acceleration? 7. For every action, there is an equal and opposite reaction, isn't there? 8. What does Newton's Law of Universal Gravitation say? 9. What do we come to know due to the Law of Conservation of Energy? 10. When is the total momentum before the collision the same as the total momentum after the collision? 11. What is Bernoulli's Principle? 12. Does classical mechanics accurately describe the behavior of most "normal" or "abnormal" objects? 13. What should an object be to be considered "normal"? 14. Is the term "classical mechanics" relatively new or old? 15. What did Newton publish in 1687? 16. What did this work unify? 17. What civilizations understood the motion of the sun, moon and stars? 18. What was the new study of how things move about the heavens called? 19. What could scientists do using Newton's laws? 20. What did classical mechanics describe?

Exercise 2. Find the English equivalents in the text. Use them in your own sentences

використовуючи лише кілька рівнянь; сили, які на них впливають, усе дослідження включає наступне, залишатися в стані спокою, залишатися в русі, зовнішня сила, бути рівною, прискорення, рівна і протилежна реакція, сила тяжіння, бути обернено пропорційним, квадрат відстані, бути створеним або знищеним, перетворитися на, за відсутності зовнішніх сил, загальний імпульс, зіткнення, в безперервній лінії потоку рідини, на відміну від, рухатися зі швидкістями, зі швидкістю світла, бути відносно новим, породжувати нові галузі дослідження, релятивістська механіка, квантова механіка, як тіла рухаються під впливом зовнішніх сил, найдавніша з усіх областей, рух сонця, місяця і зірок; міг навіть передбачати дати затемнень; те, як рухаються речі на небесах, небесна механіка, поєднати символічну математику з алгеброю та обчисленням; дізнаватися про явища, які ще не спостерігалися; описувати все.

Exercise 3. Match the sentences

1. The fundamental dimensions used in mechanics	a) as on his observations of the heavens, which he made with the newly invented telescope about 1610.
2. The study of electromagnetism	b) by the Polish astronomer Nicolaus Copernicus
3. Some quantities, such as temperature, have units but	c) the state of motion of bodies to which they are applied.
4. There are also important dimensionless numbers in nature,	d) for establishing and enforcing standard units for the sake of orderly commerce, navigation, science, and, of course, taxation.

5. Governments have traditionally been responsible	e) adds an additional fundamental dimension, electric charge, or *q*. .
6. The units used for most scientific measurements are those designated by	f) have been the subject of much philosophical speculation since Newton.
7. Neither force nor mass is very clearly defined by Newton, and both	g) such as the number $\pi = 3.14159$ …
8. Forces, on the other hand, accelerate bodies, which is to say, they change	h) are not compounded of fundamental dimensions.
9. The discovery of classical mechanics was made necessary by the publication, in 1543, of the book *De revolutionibus orbium coelestium libri VI* (“Six Books Concerning the Revolutions of the Heavenly Orbs”)	i) the International System of Units (Système International d’Unités), or SI for short. They are based on the metric system, first adopted officially by France in 1795.
10. Galileo’s fame during his own lifetime rested not so much on his discoveries in mechanics	j) are time, mass, and length.

Exercise 4. Translate the following sentences into English

1. Класична механіка - це вивчення руху тіл під дією фізичних сил. Сила - це будь-який вплив, який може змусити об'єкт змінити свою швидкість.

2. Об'єктом може бути що завгодно, від елементарної частинки до галактики.

3. Класична механіка заснована на невеликій кількості фізичних законів, які представляють собою математичні формулювання фізичного спостереження.

4. Закони, з якими ми зіткнемося, можна розділити на три класи: закони руху Ньютона, закони збереження та закони сили.

5. Як ми побачимо, три закони збереження класичної механіки (енергії, імпульсу і моменту моменту) можуть бути отримані з другого і третього законів руху Ньютона, як і перший закон Ньютона.

6. Силові закони дають нам силу, яку надає певна фізична система - стиснута пружина (закон Гука) або дві заряджені частинки (закон Кулона), наприклад.

7. Вони також повертаються до законів руху Ньютона, хоча вони не можуть бути виведені з них і самі по собі є аксіомами.

8. Крім фізичних законів, існує велика кількість визначень - які не слід плутати з законами.

9. Визначення - це просто зручний вибір. Хорошим прикладом є визначення числа π: половина відношення кола до радіуса кола.

10. У XX столітті, оскільки експериментальні спостереження привели до більш детального знання великомасштабних властивостей Всесвіту, Універсальний закон гравітації Ньютона вже не точно моделював спостережуваний Всесвіт і потребував заміни *загальною відносністю.*

(https://ukrayinska.libretexts.org/)

Exercise 5. Read the following interesting piece of information. Share your opinion with your classmates

While Newton's laws of motion serve as the foundation of classical mechanics, an alternative mathematical formulation called Hamiltonian mechanics provides a different approach to analyzing physical systems. Developed by William Rowan Hamilton in the early 19th century, this formalism uses generalized coordinates and

momenta to describe the dynamics of a system. It states that the dynamics of a physical system are determined by a variational problem for a functional based on a single function, the Lagrangian, which may contain all physical information concerning the system and the forces acting on it.

(https://en.wikipedia.org/wiki/Hamilton%27s_principle)

Speaking

- Speak about classical mechanics.
- Speak about the history of classical mechanics.
- Speak about celestial mechanics.
- Speak about Isaac Newton and his genius.

Unit 3.

I. Read and translate the text. Learn the new vocabulary

Kinematics

Kinematics is the branch of classical mechanics that describes the motion of points, objects and systems of groups of objects, without reference to the causes of motion (i.e., forces). The study of kinematics is often referred to as the "geometry of motion."

Objects are in motion all around us. Everything from a tennis match to a space-probe flyby of the planet Neptune involves motion. When you are resting, your heart moves blood through your veins. Even in inanimate objects there is continuous motion in the vibrations of atoms and molecules. Interesting questions about motion can arise: how long will it take for a space probe to travel to Mars? Where will a football land if thrown at a certain angle? An understanding of motion, however, is also key to

understanding other concepts in physics. An understanding of acceleration, for example, is crucial to the study of force.

To describe motion, kinematics studies the trajectories of points, lines and other geometric objects, as well as their differential properties (such as velocity and acceleration). Kinematics is used in astrophysics to describe the motion of celestial bodies and systems; and in mechanical engineering, robotics and biomechanics to describe the motion of systems composed of joined parts (such as an engine, a robotic arm, or the skeleton of the human body).

A formal study of physics begins with kinematics. The word “kinematics” comes from a Greek word “kinesis” meaning motion, and is related to other English words such as “cinema” (movies) and “kinesiology” (the study of human motion). Kinematic analysis is the process of measuring the kinematic quantities used to describe motion. The study of kinematics can be abstracted into purely mathematical expressions, which can be used to calculate various aspects of motion such as velocity, acceleration, displacement, time, and trajectory.

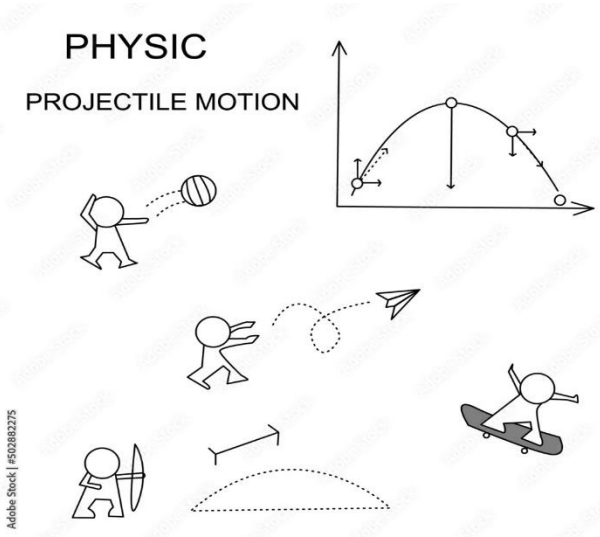

Fig. 1. Projectile motion

(From https://stock.adobe.com/ua/search?k=kinematics&asset_id=502882275)

Kinematics of a particle trajectory: Kinematic equations can be used to calculate the trajectory of particles or objects. The physical quantities relevant to the motion of a particle include: mass **m**, position **r**, velocity **v**, acceleration **a**.

In order to describe the motion of an object, you must first describe its position — where it is at any particular time. More precisely, you need to specify its position relative to a convenient reference frame. Earth is often used as a reference frame, and we often describe the position of objects related to its position to or from Earth. Mathematically, the position of an object is generally represented by the variable *x*.

Frames of Reference

There are two choices you have to make in order to define a position variable *x*. You have to decide where to put $x = 0$ and which direction will be positive. This is referred to as choosing a coordinate system, or choosing a frame of reference. As long as you are consistent, any frame is equally valid.

Displacement

Displacement is the change in position of an object relative to its reference frame. For example, if a car moves from a house to a grocery store, its displacement is the relative distance of the grocery store to the reference frame, or the house. The word "displacement" implies that an object has moved or has been displaced. Displacement is the change in position of an object and can be represented mathematically as follows:

$$\Delta x = x_f - x_0 \quad (1)$$

where Δx is displacement, x_f is the final position, and x_0 is the initial position.

Key Points

- To describe motion, kinematics studies the trajectories of points, lines and other geometric objects.
- The study of kinematics can be abstracted into purely mathematical expressions.
- Kinematic equations can be used to calculate various aspects of motion such as velocity, acceleration, displacement, and time.
- Choosing a frame of reference requires deciding where the object's initial position is and which direction will be considered positive.
- Valid frames of reference can differ from each other by moving relative to one another.
- Frames of reference are particularly important when describing an object's displacement.
- Displacement is the change in position of an object relative to its reference frame.
- A vector is any quantity that has magnitude and direction.
- A scalar is any quantity that has magnitude but no direction.
- Displacement and velocity are vectors, whereas distance and speed are scalars.

(From https://phys.libretexts.org/Bookshelves/University_Physics/)

Vocabulary

kinematics [ˌkɪnəˈmatɪks]	кінематика
a space-probe flyby	проліт космічного зонда
vein [veɪn]	вена

inanimate object [ɪˈnæn.ɪ.mətˈɒbdʒɪkt]	неживий предмет
a space probe	космічний зонд
at a certain angle	під певним кутом
acceleration [əkˌsel.əˈreɪ.ʃən]	прискорення
crucial [ˈkruːʃl]	вирішальний
trajectory [trəˈdʒek.tər.i]	траєкторія
displacement	переміщення
equation [ɪˈkweɪ.ʒən]	рівняння
convenient [kənˈviːniənt]	зручний
reference frame	система відліку
variable [ˈveə.ri.ə.bl̩]	змінна
consistent	послідовний
valid	дійсний
magnitude [ˈmæg.nɪ.tjuːd]	величина

Exercise 1. Answer the following questions

1. What is kinematics? 2. Are objects in motion all around us? Give an example. 3. Is understanding of motion also key to understanding other concepts in physics? 4. An understanding of acceleration is crucial to the study of force, isn't it? 5. What is the scope of kinematics? 6. Where is kinematics used? 7. What does the formal study of physics begin with? 8. Where does the word "kinematics" come from? 9. What is

kinematic analysis? 10. How can the study of kinematics be abstracted? 11. What can kinematic equations be used for? 12. What do the physical quantities relevant to the motion of a particle include? 13. What do you need to do to describe the motion of an object? 14. What is often used as a reference frame? 15. How is the position of an object generally represented? 16. What is referred as choosing a frame of reference? 17. When is any frame equally valid? 18. What is displacement? Give example. 19. How can displacement be represented? 20. What can you say about valid frames of reference? 21. How is vector different from a scalar? 22. What are displacement and velocity?

Exercise 2. Find the English equivalents in the text. Use them in your own sentences

галузь класичної механіки, «геометрія руху», часто згадується всюди навколо нас, рухати кров у ваших венах, кинуту під певним кутом, мати вирішальне значення для вивчення сили, для вивчення траєкторій точок , лінії та інші геометричні об'єкти; описувати рух небесних тіл і систем; системи, що складаються із з’єднаних частин, формальне вивчення фізики, процес вимірювання кінематичних величин, кінезіологія, для розрахунку різних аспектів руху; швидкість, прискорення, переміщення, час і траєкторія; що стосується фізичних величин, точніше, системи відліку, для визначення змінної положення *x*, система координат, яка однаково дійсна, може бути представлена математично таким чином, початкове положення, будь-яка величина, величина та напрямок.

Exercise 3. Match the sentences

1. Kinematics deals with the concepts	a) we will use two concepts that we have already encountered, displacement and time

2. Dynamics deals with	b) as long as the acceleration of the object is constant.
3. Together, kinematics and dynamics form	c) contains four variables.
4. To describe the motion of an object,	d) so that they share a common variable.
5. Displacement is a vector quantity	e) we now introduce the new idea of acceleration.
6. The displacement is a vector	f) the effect that forces have on motion.
7. To define the velocity of an object,	g) the branch of physics known as mechanics.
8. To describe how the velocity of an object changes during a given time interval,	h) for it conveys both a magnitude (the distance between the initial and final positions) and a direction.
9. The equations of kinematics can be applied to any moving object,	i) we must be able to specify the location of the object at all times.
10. However, remember that each equation	j) that points from an object's initial position to its final position and has a magnitude that equals the shortest distance between the two positions.
11. The motion of two objects may be interrelated,	k) in understanding the concepts of velocity and acceleration.
12. Graphical techniques are helpful	l) that are needed to describe motion, without any reference to forces.

Exercise 4. Translate the following sentences into English

1. Кінематика – це початковий розділ механіки, в якому встановлюються поняття та величини, що визначають рух, а також способи опису та загальні співвідношення між характеристиками руху без аналізу причин, які їх зумовлюють.

2. Існують різні способи опису положення і руху тіла в обраній системі відліку – векторний, координатний та природній – і відповідний набір кінематичних величин, які для цього використовуються.

3. Тверді тіла, що рухаються, не завжди можна вважати матеріальними точками. Це стосується, наприклад, рухомих деталей та вузлів механізмів і машин.

4. Рух твердих тіл можна поділити на декілька різновидів: 1) поступальний рух; 2) обертання навколо нерухомої осі; 3) плоский рух; 4) обертання навколо нерухомої точки; 5) вільний рух.

5. Динаміка – розділ механіки, в якому характер руху тіла встановлюються через аналіз причин, що його зумовлюють.

6. Основу динаміки складають три закони Ньютона, котрі є узагальненням результатів спостережень і спеціально поставлених експериментів і не виводяться з якихось більш простих принципів.

7. На відміну від решти фізичних величин, існують різні форми енергії: механічна, внутрішня (теплова), електромагнітна, ядерна, тощо.

8. Енергія має здатність перетворюватися з одних форм на інші, причому завжди так, що загальна кількість енергії у будь-якій замкненій системі лишається незмінною (закон збереження енергії).

9. В кінематиці рух описують як лінійними, так і кутовими величинами.

10. В динаміці твердого тіла теж, окрім “звичайних” характеристик (сила, маса, імпульс), використовують систему кутових динамічних величин, які називаються "моментами".

(From http://physics.zfftt.kpi.ua/mod/book/view.php?id=272&chapterid=17)

Exercise 5. Read the following interesting piece of information. Share your opinion with your classmates

Kinematics can be used to predict the future.

While kinematics is a mechanic, it is also used to study physics. In particular, kinematics can be helpful if you want to make predictions about an object’s motion before actually watching this motion take place. For example, kinematic equations could give you enough information to design a machine that moves in the way you want it to move.

Furthermore, kinematics can be used in ballistics. Ballistics is the study of how projectiles move through the air. By understanding kinematics, you can predict an object’s trajectory and how much force it will take to make it to a specific destination.

(https://www.enostech.com/6-interesting-things-to-understand-about-kinematics/)

Speaking

- Speak about kinematics.
- Speak about kinematics in two dimensions.
- Speak about basic concepts of kinematics.
- Speak about kinematic constrains.

Unit 4.

I. Read and translate the text. Learn the new vocabulary

Statics and Forces

Statics, in physics, the subdivision of mechanics that is concerned with the forces that act on bodies at rest under equilibrium conditions. Its foundations were laid more than 2,200 years ago by the ancient Greek mathematician Archimedes and others while studying the force-amplifying properties of simple machines such as the lever and the axle. The methods and results of the science of statics have proved especially useful in designing buildings, bridges, and dams, as well as cranes and other similar mechanical devices. To be able to calculate the dimensions of such structures and machines, architects and engineers must first determine the forces that act on their interconnected parts. Statics provides the analytical and graphical procedures needed to identify and describe these unknown forces.

Statics assumes that the bodies with which it deals are perfectly rigid. It also holds that the sum of all the forces acting on a body at rest has to be zero (i.e., the forces involved balance one another) and that there must be no tendency for the forces to turn the body about any axis. These three conditions are independent of one another, and their expression in mathematical form comprises the equations of equilibrium. There are three equations, and so only three unknown forces can be calculated. If more than three unknown forces exist, it means that there are more components in the structure or machine than are required to support the applied loads or that there are more restraints than are needed to keep the body from moving. Such unnecessary components or restraints are termed redundant (e.g., a table with four legs has one redundant leg) and the system of forces is said to be statically indeterminate. The number of equations available in statics is limited because of a neglect of the deformations of loaded bodies,

a direct consequence of the underlying premise that any solid body under consideration is ideally rigid and immutable as to shape and size under all conditions.

So, Statics is a course about forces. At its simplest, a force is a "push or pull," but forces come from a variety of sources and occur in many different situations. As such we need a specialized vocabulary to talk about them. We are also interested in forces that cause rotation, and we have special terms to describe these too.

Some terms used to describe forces are given below.

Point Forces, also called ***concentrated forces***, are forces that act at a single point. Examples are the push you give to open a door, the thrust of a rocket engine, or the pull at the chain suspending a wrecking ball. Point forces are actually an idealization, because real forces always act over an area and not at a mathematical point. However, point forces are the easiest type to deal with computationally so we will usually represent other types of forces as equivalent concentrated forces.

Distributed forces are forces that are spread out over a line, area or volume. Steam pressure in a boiler and the weight of snow on a roof are examples of forces distributed over an area. Distributed forces are represented graphically by an array of force vectors.

Body forces are distributed forces acting over the volume of a body. The most common body force is the body's weight, but there are others including buoyancy and forces caused by electric and magnetic fields.

In many situations, body forces are small in comparison to the other forces acting on the object, and as such may be neglected. In practice, the decision to neglect forces must be made on the basis of sound engineering judgment.

Loads are the forces which an object must support in order to perform its function. Loads can be either static or dynamic, however only static loads will be considered here. Forces which hold a loaded object in equilibrium or hold parts of an object together are not considered loads.

Reaction forces or simply ***reactions*** are the forces and moments which hold or constrain an object or mechanical system in equilibrium. They are called the reactions because they react when other forces on the system change. If the load on a system increases, the reaction forces will automatically increase in response to maintain equilibrium.

Internal forces are forces which hold the parts an object or system together.

As an example of the various types of forces, consider a heavy crate being pulled by a rope across a rough surface: **(a)** Pull - Concentrated force, **(b)** Weight - Body force, **(c)** Friction - Distributed force, **(d)** Normal Force - Distributed force.

The pull of the rope and the weight of the crate are *loads*. The rope applies a force at a single point, so is a *concentrated force*. The force of the ground holding the crate in equilibrium is a *reaction force*. This force can be divided into two components: a ***tangential*** friction component which acts parallel to the ground and resists the pull of the cable, and a ***normal*** component which acts perpendicular to the bottom surface and supports the crate's weight. The normal and tangential components are *distributed forces* since they act over the bottom surface area. The weight is also a distributed force, but one that acts over the entire crate so it's considered a *body force*.

(From https://www.britannica.com/science/statics;
https://engineeringstatics.org/backmatter.html)

Vocabulary

equilibrium [ˌek.wɪˈlɪb.ri.əm] [ˌiː.kwɪˈlɪb.ri.əm]	рівновага
Archimedes [ˌɑː.kɪˈmiː.diːz]	Архімед
to amplify [ˈæm.plɪ.faɪ]	посилювати
lever UK [ˈliː.vər] US]ˈlev.ɚ]	важіль

axle [ˈæk.səl]	вал, ведучий міст
dam [dæm]	дамба
dimension [ˌdaɪˈmen.ʃən] [ˌdɪˈmen.ʃən]	вимір
rigid [ˈrɪdʒ.ɪd]	жорсткий
axis [ˈæk.sɪs]	вісь
restraint [rɪˈstreɪnt]	обмеження
redundant [rɪˈdʌn.dənt]	надлишковий
indeterminate [ˌɪn.dɪˈtɜː.mɪ.nət]	невизначений
to neglect [nɪˈglekt]	нехтувати
immutable [ɪˈmjuː.tə.bəl]	незмінний
to push [pʊʃ]	штовхати
to pull [pʊl]	тягнути
rotation [rəʊˈteɪ.ʃən]	обертання
point forces	точкові сили
thrust [θrʌst]	тяга
to suspend [səˈspend]	призупинити
wrecking [rekɪŋ]	руйнівний
distributed forces	розподілені сили
an array [əˈreɪ]	масив

buoyancy [ˈbɔɪ.ən.si]	плавучість
to constrain [kənˈstreɪn]	обмежити
a heavy crate	важкий ящик
a tangential [tænˈdʒen.ʃəl]	тангенс; дотична
friction [ˈfrɪk.ʃən]	тертя

Exercise 1. Answer the following questions

1.What is statics? 2. Who laid the foundations of it? 3. What have the methods and results of the science of statics proved? 4. What must architects and engineers first determine to calculate the dimensions of structures and machines? 5. What does statics assume? 6. What comprises the equations of equilibrium? 7. What does it mean if more than three unknown forces exist? 8. When is the system of forces said to be statically indeterminate? 9. Why is the number of equations available in statics limited? 10. What is a force at its simplest? 11. Why are we interested in forces? 12. What are Point Forces? 13. What are distributed forces? 14. What are body forces? 15. What are loads? 16. What are reactions? 17. What can you say about internal forces? 18. The force of the ground holding the crate in equilibrium is a reaction force, isn't it? 19. What components can a concentrated force be divided into? 20. Why are the normal and tangential components distributed forces? 21. What is weight?

Exercise 2. Find the English equivalents in the text

підрозділ механіки, у стані спокою, в умовах рівноваги, давньогрецький математик, властивості посилення сили простих машин, важіль і вісь, особливо корисні, подібні механічні пристрої, визначити сил, взаємопов'язані частини, ідентифікувати та описати, включати рівняння рівноваги, підтримувати

прикладені навантаження, утримувати тіло від руху, називається надлишковим, прямим наслідком, ідеально жорстким і незмінним, «поштовх або тяга», різноманітні джерела, викликати обертання, спеціальні терміни для опису, точкові сили, тяга ракетного двигуна; ланцюг, що підвішує руйнівну кулю; у математичній точці, розподілені сили, тиск пари, який потрібно представити графічно, масив векторів сил, сили тіла, можна знехтувати, на основі правильного інженерного судження, для виконання своєї функції, сили реакції, обмеження об'єкта, підтримувати рівновагу, у відповідь на внутрішні сили, компонент дотичного тертя.

Exercise 3. Match the sentences

1. Statics is the gateway into engineering mechanics, which is the application of Newtonian physics	a) which may be examined as a unit.
2. The subject is called "statics" because	b) can be described by a positive or negative number, or even zero.
3. *Scalars* are physical quantities that have no associated direction and	c) it is concerned with particles and rigid bodies that are in equilibrium, and these will usually be stationary, i.e. static.
4. Scalar quantities follow the usual laws of algebra, and most scalar quantities	d) to design and analyze objects, systems, and structures with respect to motion, deformation, and failure.
5. The primary vector quantity you will encounter in statics will be *force*, but	e) an object which doesn't bend, stretch, or twist when forces are applied to it.
6. A *body* is an object, possibly made up of many parts,	f) velocity's time rate of change and is a vector quantity.

7. A *rigid body* is a body that doesn't deform under load, that is to say,	g) *moment and position* are also important vectors.
8. A body in *equilibrium* is not accelerating. As you learned in physics, acceleration is	h) all expected external loads, including live loads, dead loads, wind and earthquake loads.
9. A properly designed structure must safely support	i) the weight of building materials and the force of wind, water, or earth pushing on a surface.
10. In a successful design, the shape, size, and material	j) a one-dimensional curve, a two-dimensional area or a three-dimensional volume.
11. A *centroid* is the geometric center of a geometric object:	k) must all be carefully chosen to limit them to safe values.
12. *Distributed loads* are forces which are spread out over a length, area, or volume. Most real-world loads are distributed, including	l) have units. Mass, time, temperature, and length are all scalars.

Exercise 4. Translate the following sentences into English

1. Статика — розділ теоретичної механіки, в якому викладаються загальні відомості про сили та встановлюються умови рівноваги матеріальних тіл під дією різних систем сил.

2. Під рівновагою тіла розуміють його стан відносного спокою або рівномірного прямолінійного руху. Умови рівноваги істотно залежать від того, яке це тіло — тверде, рідке або газоподібне.

3. Одним з основних понять у статиці є поняття про силу.

4. Сила у механіці є кількісною мірою механічної взаємодії одного тіла з іншим.

5. За спостереженнями сила, що діє на тіло, є векторною величиною, яка характеризується трьома параметрами: модулем F ρ (або F), лінією дії (AB) й точкою прикладання — A.

6. Сукупність кількох сил, що діють на тіло, називається системою сил.

7. Дві сили, що діють на вільне абсолютно тверде тіло, зрівноважуються тоді і тільки тоді, коли вони однакові за модулем і спрямовані вздовж однієї прямої у протилежних напрямах.

8. Все те, що обмежує переміщення даного тіла в просторі, являє собою в'язі.

9. Сили, з якими в'язі діють на тіло, називаються реакціями в'язей.

10. Якщо тіло під дією трьох непаралельних сил, що лежать в одній площині, перебуває в рівновазі, то лінії дії цих сил перетинаються в одній точці.

(From https://www.dstu.dp.ua/Portal/Data/1/5/1-5-b8.pdf)

Exercise 5. Read the following interesting piece of information. Share your opinion with your classmates

Earth's gravity keeps the Moon in orbit around the planet. Gravitational pull varies from planet to planet in the solar system depending on their size. For example, Jupiter's gravitational pull is two and a half times greater than Earth's! It means that the gravitational force exerted by Jupiter on an object at its surface is 2.4 times stronger than the gravitational force exerted by Earth on an object at its surface. However, the reason we are not pulled into Jupiter's orbit despite its stronger gravity is because the effect of gravity depends not only on the strength of the gravitational force but also on the distance between the objects and their masses.

(https://www.quora.com/If-Jupiters-gravity-is-2-4-times-that-of-the-Earth-why-arent-we-pulled-into-Jupiters-orbit)

Speaking

- Speak about Statics.
- Speak about Forces and other Vectors.
- Speak about Rigid Body Equilibrium.

Unit 5.

I. Read and translate the text. Learn the new vocabulary

Energy of a system

The definitions of quantities such as position, velocity, acceleration, and force and associated principles such as Newton's second law have allowed us to solve a variety of problems. Some problems that could theoretically be solved with Newton's laws, however, are very difficult in practice, but they can be made much simpler with a different approach. This new approach, which will include definitions of quantities that may not be familiar to you. Other quantities may sound familiar, but they may have more specific meanings in physics than in everyday life. We begin this discussion by exploring the notion of energy. The concept of energy is one of the most important topics in science and engineering. In everyday life, we think of energy in terms of fuel for transportation and heating, electricity for lights and appliances, and foods for consumption. These ideas, however, do not truly define energy. They merely tell us that fuels are needed to do a job and that those fuels provide us with something we call energy. Energy is present in the Universe in various forms. Every physical process that occurs in the Universe involves energy and energy transfers or transformations. Unfortunately, despite its extreme importance, energy cannot be easily defined.

Although we have experiences with energy, such as running out of gasoline or losing our electrical service following a violent storm, the notion of energy is more abstract.

The concept of energy can be applied to mechanical systems without resorting to Newton's laws. Furthermore, the energy approach allows us to understand thermal and electrical phenomena. We begin our new approach by focusing our attention on a new simplification model, a system, and analysis models based on the model of a system.

In the system model, we focus our attention on a small portion of the Universe—the system—and ignore details of the rest of the Universe outside of the system. A critical skill in applying the system model to problems is identifying the system. A valid system

• may be a single object or particle

• may be a collection of objects or particles

• may be a region of space (such as the interior of an automobile engine combustion cylinder)

• may vary with time in size and shape (such as a rubber ball, which deforms upon striking a wall. Identifying the particular system is a second part of this step. No matter what the particular system is in a given problem, we identify a system boundary, an imaginary surface (not necessarily coinciding with a physical surface) that divides the Universe into the system and the environment surrounding the system. As an example, imagine a force applied to an object in empty space. We can define the object as the system and its surface as the system boundary. The force applied to it is an influence on the system from the environment that acts across the system boundary. The system can also be defined as the combination of the ball, the block, and the cord. The influence from the environment includes the gravitational forces on the ball and the block, the normal and friction forces on the block, and the force exerted by the

pulley on the cord. The forces exerted by the cord on the ball and the block are internal to the system and therefore are not included as an influence from the environment. There are a number of mechanisms by which a system can be influenced by its environment. The first one we shall investigate is work.

Work is a scalar; there is no direction associated with it. All types of energy and energy transfer are scalars. This fact is a major advantage of the energy approach because we don't need vector calculations!

(From Physics for Scientists and Engineers with Modern Physics, Raymond A. Serway, John W.Jewett Jr., pp.177-178)

Vocabulary

velocity [vəˈlɒs.ə.ti]	швидкість
acceleration [əkˌsel.əˈreɪ.ʃən]	прискорення
approach [əˈprəʊtʃ]	підхід
to be familiar to [fəˈmɪl.i.ər]	бути знайомим
fuel [ˈfjuː.əl]	пальне
consumption [kənˈsʌmp.ʃən]	споживання
the Universe [ˈjuː.nɪ.vɜːs]	всесвіт
define [dɪˈfaɪn]	визначити
gasoline [ˈgæs.əl.iːn]	бензин
valid [ˈvæl.ɪd]	дійсний
combustion [kəmˈbʌs.tʃən]	горіння

a system boundary [ˈsɪs.təm ˈbaʊn.dər.i]	межа системи
cord [kɔːd]	шнур
friction force [ˈfrɪk.ʃən fɔːs]	сила тертя
investigate [ɪnˈves.tɪ.geɪt]	розслідувати
scalar [ˈskeɪ.lər]	скаляр; скалярний

Exercise 1. Answer the following questions

1. What are the definitions of quantities associated with? 2. What do they allow us to solve? 3. What problems are very difficult in practice? 4. What will the new approach include? 5. May other quantities sound familiar? 6. What can you say about the concept of energy? 7. How do we think of energy in everyday life? 8. Do these ideas truly define energy? What do they tell us? 9. Energy is present in the Universe in various forms, isn't it? 10. What does every physical process involve? 11. Energy cannot be easily defined, can it? 12. What experiences connected with energy do we have? 13. How can the concept of energy be applied to mechanical systems? 14. How do we begin our new approach? 15. Do we take into consideration or ignore details of the rest of the Universe outside of the system? 16. Is identifying the system a critical skill in applying the system model to problems? 17. What can be said of a valid system? 18. Is identifying the particular system a second part of this step? 19. How do we identify a system boundary? 20. How can we define the object? 21. What is the force applied to it? 22. How can the system also be defined? 23. There are a number of mechanisms by which a system can be influenced by its environment, aren't there? 24. What is work? 25. Why is this work a major advantage?

Exercise 2. Find the English equivalents in the text. Use them in your own sentences

визначення величин, швидкості, прискорення та сили; Другий закон Ньютона, вирішити різноманітні проблеми, інший підхід, паливо, споживання, механічні системи, дійсна система, набір об'єктів або частинок, циліндр внутрішнього згоряння автомобільного двигуна, межа системи; сила, прикладена до неї; шнур, сили тяжіння, шків, скаляр, головна перевага, підхід, векторні обчислення.

Exercise 3. Match the sentences

1. As an example of the distinction between the definition of work and our everyday understanding of the word,	a) can be described as a transfer of energy across the system boundary.
2. At the end of this time interval, your tired arms may lead you to think	b) if the force does not move through a displacement.
3. According to our definition, however, you have done no work on it whatsoever. You exert a force to support the chair,	c) although gravity is not the cause of the object moving upward!
4. A force does no work on an object	d) you have done a considerable amount of work on the chair.
5. We can calculate the work done by a force on an object,	e) is that the system changes its speed.
6. For example, if you lift an object, (negative) work is done on the object by the gravitational force,	f) that work is an energy transfer.

7. An important consideration for a system approach to problems is	g) but you do not move it.
8. If a system interacts with its environment, this interaction	h) is a scalar quantity and has the same units as work.
9. One possible result of doing work on a system	i) but that force is not necessarily the cause of the object's displacement.
10. Kinetic energy represents the energy associated with the motion of the particle. Note that kinetic energy	j) consider holding a heavy chair at arm's length for 3 min.

Exercise 4. Translate the following sentences into English

1. Енергія – це скалярна фізична величина яка є мірою різних форм руху матерії та є характеристикою стану системи (тіла) і визначає максимальну роботу, котру може виконати тіло (система).

2. Тіла володіють енергією: кінетичною енергією – внаслідок руху масивного тіла; потенціальною енергією – внаслідок взаємодії з іншими тілами, полями; тепловою (внутрішньою) енергією – внаслідок хаотичного руху і взаємодії своїх молекул, атомів, електронів.

3. Повну механічну енергію складають кінетична та потенціальна енергія.

4. Кінетична енергія масивного тіла m, яке рухається поступально зі швидкістю ***v*** шукають за формулою: $E_к = К = mv^2/2$

5. Потенціальною називають частину механічної енергії, яка залежить від взаємного розташування тіл у системі та їх положення в зовнішньому силовому полі.

6. В стані рівноваги потенціальна енергія набуває мінімального значення.

7. Механічна енергія консервативної системи тіл залишається постійною в процесі руху системи: ***E = K + П = const***

8. Якщо система взаємодіючих тіл замкнута але неконсервативна, то її механічна енергія не зберігається.

9. Якщо система взаємодіючих тіл незамкнута та неконсервативна, то її механічна енергія не зберігається.

10. Зміна механічної енергії такої системи дорівнює сумарній роботі внутрішніх та зовнішніх непотенціальних сил.

(From https://dobrafiz.blogspot.com/2017/11/blog-post_14.html)

Exercise 5. Read the following interesting piece of information. Share your opinion with your classmates

The word 'energy' is derived from ancient Greece

'Energy' may be a staple in 21st century dictionaries but the term is derived from the Greek word 'energeia' which was created by Aristotle in 384 BC. While it has no direct translation in English, linguistic experts say the world 'energeia' describes a "state of being at work."

A single wind turbine can power 1400 homes

Wind turbines are lauded as an energy source of the future, with the enormous wings of a 2.5MW turbine generating enough electricity to power 1400 homes. This is enough to boil hundreds of thousands of kettles and make 230 million cups of tea, or power a household computer for more than 2000 years.

The UK is currently powered by more than 10,000 wind turbines with a total capacity of 22 gigawatts. This makes the country one of the largest producers of wind power in the world. Many of Britain's turbines are built in China, where factories manufacture around two wind turbines every hour.

10 Google searches can power a 60-watt lightbulb

Google processes around 3.5 billion searches per day, or around 40,000 every second. While it takes a matter of seconds to type a query and press enter, conducting 10 Google searches chews through enough energy to power a 60-watt lightbulb.

(From https://www.valdaenergy.com/blogs/8-fun-energy-facts)

Speaking

- Speak about work, energy and power.
- What are examples of energy systems?
- What are the main 5 types of energy found in systems?

Unit 6.

I. Read and translate the text. Learn the new vocabulary

The Nature of Heat

Heat, energy that is transferred from one body to another as the result of a difference in temperature. If two bodies at different temperatures are brought together, energy is transferred—i.e., heat flows—from the hotter body to the colder. The effect of this transfer of energy usually, but not always, is an increase in the temperature of the colder body and a decrease in the temperature of the hotter body. A substance may absorb heat without an increase in temperature by changing from one physical state (or phase) to another, as from a solid to a liquid (melting), from a solid to a vapour (sublimation), from a liquid to a vapour (boiling), or from one solid form to another (usually called a crystalline transition). The important distinction between heat and temperature (heat being a form of energy and temperature a measure of the amount of that energy present in a body) was clarified during the 18th and 19th centuries.

Heat as a form of energy

Because all of the many forms of energy, including heat, can be converted into work, amounts of energy are expressed in units of work, such as joules, foot-pounds, kilowatt-hours, or calories. Exact relationships exist between the amounts of heat added to or removed from a body and the magnitude of the effects on the state of the body. The two units of heat most commonly used are the calorie and the British thermal unit (BTU). The calorie (or gram-calorie) is the amount of energy required to raise the temperature of one gram of water from 14.5 to 15.5 °C; the BTU is the amount of energy required to raise the temperature of one pound of water from 63 to 64 °F. One BTU is approximately 252 calories. Both definitions specify that the temperature changes are to be measured at a constant pressure of one atmosphere, because the amounts of energy involved depend in part on pressure. The calorie used in measuring the energy content of foods is the large calorie, or kilogram-calorie, equal to 1,000 gram-calories.

In general, the amount of energy required to raise a unit mass of a substance through a specified temperature interval is called the heat capacity, or the specific heat, of that substance. The quantity of energy necessary to raise the temperature of a body one degree varies depending upon the restraints imposed. If heat is added to a gas confined at constant volume, the amount of heat needed to cause a one-degree temperature rise is less than if the heat is added to the same gas free to expand (as in a cylinder fitted with a movable piston) and so do work. In the first case, all the energy goes into raising the temperature of the gas, but in the second case, the energy not only contributes to the temperature increase of the gas but also provides the energy necessary for the work done by the gas on the piston. Consequently, the specific heat of a substance depends on these conditions. The most commonly determined specific heats are the specific heat at constant volume and the specific heat at constant pressure. The heat capacities of many solid elements were shown to be closely related to their atomic weights by the French scientists Pierre-Louis Dulong and Alexis-Thérèse Petit in 1819.

The so-called law of Dulong and Petit was useful in determining the atomic weights of certain metallic elements, but there are many exceptions to it; the deviations were later found to be explainable on the basis of quantum mechanics.

It is incorrect to speak of the heat in a body, because heat is restricted to energy being transferred. Energy stored in a body is not heat (nor is it work, as work is also energy in transit). It is customary, however, to speak of sensible and latent heat. The latent heat, also called the heat of vaporization, is the amount of energy necessary to change a liquid to a vapour at constant temperature and pressure. The energy required to melt a solid to a liquid is called the heat of fusion, and the heat of sublimation is the energy necessary to change a solid directly to a vapour, these changes also taking place under conditions of constant temperature and pressure.

Air is a mixture of gases and water vapour, and it is possible for the water present in the air to change phase; i.e., it may become liquid (rain) or solid (snow). To distinguish between the energy associated with the phase change (the latent heat) and the energy required for a temperature change, the concept of sensible heat was introduced. In a mixture of water vapour and air, the sensible heat is the energy necessary to produce a particular temperature change excluding any energy required for a phase change.

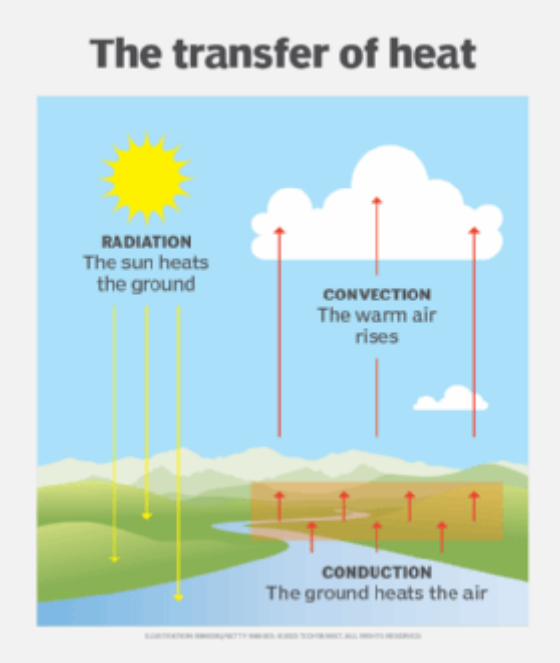

Fig.1. The transfer of heat

(From https://www.techtarget.com//whatis/definition/heat)

Heat transfer

Because heat is energy in transition, some discussion of the mechanisms involved is pertinent. There are three modes of heat transfer, which can be described as (1) the transfer of heat by conduction in solids or fluids at rest, (2) the transfer of heat by convection in liquids or gases in a state of motion, combining conduction with fluid flow, and (3) the transfer of heat by radiation, which takes place with no material carrier. The flow of heat in metal bars was studied analytically by the French mathematician Jean-Baptiste-Joseph Fourier and measured by the French physicist Jean-Baptiste Biot in 1816. The conductivity of water was first determined in 1839; the conductivity of gases was not measured until after 1860. Biot formulated the laws of conduction in 1804, and Fourier published a mathematical description of this phenomenon in 1822. In 1803 it was found that infrared rays are reflected and refracted as visible light is, and, thenceforth, the study of thermal radiation became part of the study of radiation in general. In 1859 a physicist in Germany, Gustav Robert Kirchhoff,

presented his law of radiation, relating emissive power to absorptivity. An Austrian, Josef Stefan, established the relationship (now called the Stefan-Boltzmann law) between the energy radiated by a blackbody and the fourth power of its temperature. Ludwig Boltzmann established the mathematical basis for this law of radiation in 1884. It was in the study of radiation that Max Planck arrived at the concept of the quantum. Understanding of heat transfer by convection was developed during the period 1880–1920, although an equation describing such processes had been suggested by Sir Isaac Newton in 1701.

(From https://www.britannica.com/science/heat)

Vocabulary

an increase [ɪnˈkriːs]	збільшення
a decrease [dɪˈkriːs] UK [ˈdiː.kriːs]	зменшення
a solid	тверда речовина
a liquid [ˈlɪk.wɪd]	рідина
a vapour [ˈveɪ.pər]	пара
a crystalline [ˈkrɪs.təl.aɪn]	кристалічний
joule (J) [dʒuːl]	джоуль
thermal [ˈθɜː.məl]	теплові
to specify [ˈspes.ɪ.faɪ]	вказати
a substance [ˈsʌb.stəns]	речовина
heat capacity [hiːt]	теплоємність

a restraint [rɪˈstreɪnt]	витримка, обмежувач
to impose [ɪmˈpəʊz]	накладати
confined to [kənˈfaɪnd]	обмежений
to expand [ɪkˈspænd]	розширювати
piston [ˈpɪs.tən]	поршень
consequently [ˈkɒn.sɪ.kwənt.li]	отже
volume [ˈvɒl.juːm]	обсяг
pressure [ˈpreʃ.ər]	тиск
to determine [dɪˈtɜː.mɪn]	визначити
deviation [ˌdiː.viˈeɪ.ʃən]	відхилення
to be restricted to	бути обмеженим
sensible [ˈsen.sə.bəl]	розумний
pertinent [ˈpɜː.tɪ.nənt]	доречний
convection [kənˈvek.ʃən]	конвекція
conductivity [ˌkɒn.dʌkˈtɪv.ə.ti]	провідність
thenceforth [ˌðensˈfɔːθ]	відтоді

Exercise 1. Answer the following questions

1. What is heat? 2. What happens if two bodies at different temperatures are brought together? 3. What is the effect of this transfer of energy? 4. May a substance

absorb heat without an increase in temperature? 5. What is the important distinction between heat and temperature? 6. Can heat be converted into work? 7. What are the calorie and the British thermal unit (BTU)? 8. What is called the heat capacity? 9. What does the quantity of energy necessary to raise the temperature of a body one degree vary on? 10. What are the most commonly determined specific heats? 11. What was the so-called law of Dulong and Petit useful in? 12. Is it incorrect to speak of the heat in a body? Why? 13. What is the latent heat? 14. What is called the heat of fusion? 15. What is the heat of sublimation? 16. Why was the concept of sensible heat introduced? 17. How many models of heat transfer are there? Describe them? 18. What was studied by the French mathematician Jean-Baptiste-Joseph Fourier and measured by the French physicist Jean-Baptiste Biot in 1816? 19. When was the conductivity of water first determined? 20. What was found in 1803? 21. What deiscoveried were made in the 19th century related to heat?

Exercise 2. Find the English equivalents in the text

різниця в температурі, теплові потоки, підвищення температури, шляхом переходу з одного агрегатного стану (або фази) в інший, з твердого тіла в рідину (плавлення), з твердого тіла в пару (сублімація), з рідини до пари (кипіння), важлива відмінність, форма енергії, яку можна перетворити на роботу; величина ефектів, підвищити температуру, заданий температурний інтервал, теплоємність, сприяти температурі, залежати за цих умов, бути тісно пов’язаними з їхніми атомними вагами, певні металеві елементи, бути поясненими на основі квантової механіки, говорити про відчутне та приховане тепло, плавити тверде тіло в рідину, теплота плавлення, за умов постійної температури та тиску, створювати певну температуру, зміни фази, режими теплообміну, потік рідини, що підлягає вимірюванню; закони провідності, вивчення теплового випромінювання, поглинання, прийти до поняття кванта, запропонувати рівняння.

Exercise 3. Match the sentences

1. Heat is the transfer of thermal energy from one physical system to another system or	a) when two systems are in direct contact and the temperature of one system is higher than the temperature of the other.
2. A system, in such an instance, might be a mug of coffee, room full of air, cast-iron frying pan, mountain lake, piece of scrap metal, or	b) - all of which are systems.
3. Thermal energy tends to move from an object or region with a higher temperature	c) and manufacturing goods.
4. Heat plays a critical role in the lives of humans and other organisms	d) when the motion of a liquid or gas carries thermal energy from a warmer region within a system to a cooler region.
5. For humans, heat helps in preparing foods, warming homes	e) whereas heat is concerned with the transfer of thermal energy, which results from the kinetic energy generated by moving particles.
6. Heat generated by sunlight helps plants	f) or British thermal units (BTU).
7. Temperature is the measure of the average kinetic energy of a system's atomic particles,	g) to one with a lower temperature.

8. Temperatures can be measured	h) by the formula $J = kg \cdot m^2 \cdot s^{-2}$, where *kg* is kilograms and *s* is seconds.
9. Heat can be measured in joules (J), calories (cal)	i) in Fahrenheit, Celsius or Kelvin.
10. A joule can also be expressed	j) to mature and develop fruit, and heat also helps to shape local and global weather patterns.
11. Heat by conduction takes place	k) from one region in a physical system to another region.
12. Heat by convection occurs	l) any number of other physical objects or substances, including an energy source such as a campfire or the sun.

Exercise 4. Translate the following sentences into English

1. Передача тепла або теплообмін (теплопередача) – це процес поширення внутрішньої енергії в просторі з різними температурами.

2. Теплопровідність – це здатність речовин і тіл проводити енергію (тепло) від частин з високою температурою до частин з низькою.

3. Така здатність існує внаслідок руху частинок. Енергія може передаватися між тілами і всередині одного тіла. Нагріваючи в полум'ї один кінець цвяха, ми ризикуємо обпектися об інший його кінець, що не знаходиться в полум'ї.

4. На початку розвитку науки про властивості тіл і речовин вважалося, що тепло передається шляхом перетікання якогось елемента між тілами. Пізніше, з розвитком фізики, теплопровідність отримала пояснення взаємодією частинок речовини.

5. Теплопровідність – це властивість матеріалів передавати через свій об'єм потік тепла шляхом обміну енергією руху частинок.

6. Конвекція – це перенесення тепла, що здійснюється шляхом переміщенням нерівномірно прогрітих ділянок середовища (газу, рідини) в просторі.

7. Випромінювання (у випадку теплопровідності) – це перенесення тепла в вакуумі або газовому середовищі за допомогою електромагнітними хвилями.

8. У твердих тілах теплопровідність є основним видом теплообміну (теплопередачі) і безпосередньо залежна від природи речовини, його щільності, хімічного складу, вологості, температури.

9. У вакуумі тепло не проводиться (його теплопровідність дорівнює нулю). Передача тепла у вакуумі може відбуватися за допомогою випромінювання. Таким способом тепло сонця доходить до нашої планети.

10. Матеріал з найвищою теплопровідністю називається графен, який активно використовується в наноелектроніці.

(From https://naukozavr.info/fizuka/teploobmin-teploperedacha/)

Exercise 5. Read the following interesting piece of information. Share your opinion with your classmates

- A substance containing more heat does not always mean that its temperature is also high.
- A cup of tea at 50º C has a lot more heat than a drop of water at 99º.
- Each material has a certain capacity to hold the heat at a particular temperature. It is called the heat capacity.
- A cup of water at 99º C will not warm up the bucket of water. But, another half filled bucket at 60º C can warm up the water in the first It is because half filled bucket has more heat than the cup of water at 99º C.

(*From https://science4fun.info/heat/*)

Speaking

- Speak about the nature of heat.
- Speak about heat transfer.
- Speak about the study of heat, thermodynamics, and statistical mechanics.

Unit 7.

I. Read and translate the text. Learn the new vocabulary

Transformation of Heat into Work

Heat and work are two different ways of transferring energy from one system to another. The distinction between **Heat and Work** is important in the field of thermodynamics.

Thermodynamics is the study of how heat can be transformed into useful energy in the form of work, hence the name *thermo* + *dynamics*. It is an extremely vast and intricate area of science which took many years to develop, beginning in the early 19th century. Scientists were beginning to understand the possibility of attaining work from a heat source, and this was first demonstrated by James Joule in the 1840s. Thermodynamics gives the foundation for heat engines, power plants, chemical reactions, refrigerators, and many more important concepts that the world we live in today relies on.

Beginning to understand thermodynamics requires knowledge of how the microscopic world operates. Some key ideas that describe the microscopic properties of a system include temperature, pressure and internal energy. Understanding the properties of a system is crucial, but even more so is the transfer of this energy to other

systems, known as heat transfer. An analysis of these ideas led scientists to the formulation of the four laws of thermodynamics.

Heat is the transfer of thermal energy between systems, while work is the transfer of mechanical energy between two systems.

Mechanical energy can be converted into heat, and heat can be converted into some mechanical energy. This important physical observation is known as the mechanical equivalent of heat. This means one can change the internal energy of a system by either doing work to the system, or adding heat to the system. This concept is fundamental to thermodynamics which applies the ideas of heat and work in order to create useful systems such as engines, power plants, and refrigerators.

This distinction between the microscopic motion (heat) and macroscopic motion (work) is crucial to how thermodynamic processes work. Heat can be transformed into work and vice verse, but they aren't the same thing.

The first law of thermodynamics states that heat and work both contribute to the total internal energy of a system, but the second law of thermodynamics limits the amount of heat that can be turned into work.

Main Differences

- The Second Law allows work to be transformed fully into heat, but forbids heat to be totally converted into work. If heat could be transformed fully into work it would violate the laws of entropy. The maximum amount of work one can attain from heat is given by the Carnot efficiency.

- Heat is the energy associated with the random motion of particles, while work is the energy of ordered motion in one direction. Therefore, heat is "low-quality" energy and work is "high-quality" energy, and this supports the entropy statement of the Second Law.

Heat and work each have their own distinct properties, and they differ in how they affect a system. These are listed and compared below:

Work (W)	Heat (Q)	
Interaction	Mechanical	Thermal
Requires	Force and Displacement	Temperature difference
Process	Macroscopic pushes and pulls	Microscopic collisions
Positive value	W > 0 when a gas is compressed. Energy is transferred into system.	Q > 0 when the environment is at a higher temperature than the system. Energy is transferred into system.
Negative value	W < 0 when a gas expands. Energy is transferred out of system.	Q < 0 when the system is at a higher temperature than the environment. Energy is transferred out of system.
Equilibrium	A system is in mechanical equilibrium when there is no net force or torque on it.	A system is in thermal equilibrium when it is at the same temperature as the environment.

(From https: //energyeducation.ca/encyclopedia/Heat_vs_work)

Vocabulary

thermodynamics [θɜː.məʊ.daɪˈnæm.ɪks]	термодинаміка

hence [hens]	отже
intricate [ˈɪn.trɪ.kət]	заплутаний
to attain [əˈteɪn]	досягти
heat engine	тепловий двигун
power plant	електростанція
internal [ɪnˈtɜː.nəl]	внутрішній
crucial [ˈkruː.ʃəl]	вирішальний
heat transfer	теплопередача
observation [ˌɒb.zəˈveɪ.ʃən]	спостереження
violate [ˈvaɪ.ə.leɪt]	порушувати
entropy [ˈen.trə.pi]	ентропія
the Carnot efficiency	коефіцієнт Карно
random [ˈræn.dəm]	випадковий
interaction [ˌɪn.təˈræk.ʃən]	взаємодія
to expand [ɪkˈspænd]	розширювати
torque [tɔːk]	крутний момент

Exercise 1. Answer the following questions

1. Are heat and work two different ways of transferring energy from one system to another? 2. What is thermodynamics? 3. How many years did it take to

develop thermodynamics? 4. What was first demonstrated by James Joule in the 1840s? 5. What does thermodynamics give? 6. What does beginning to understand thermodynamics require? 7. What are some key ideas? 8. Why is the understanding the properties of a system crucial? 9. What is known as heat transfer? 10. What did the analysis of these ideas lead scientists to? 11. What is the difference between heat and work? 12. What can mechanical energy be converted into? 13. What can heat be converted into? 14. What is understood under "the mechanical equivalent of heat"? 15. Why is this concept fundamental to thermodynamics? 16. What is crucial to thermodynamic process work? 17. Can heat be transformed into work? 18. What does the first law of thermodynamics state? 19. What does the second law of thermodynamics forbid? 20. Why is heat low-quality energy? 21. How do heat and work differ? Explain.

Exercise 2. Find the English equivalents in the text

різні способи передачі енергії, сфера термодинаміки, у формі роботи, надзвичайно обширна і заплутана область науки, розроблялася багато років, можливість досягнення роботи від джерела тепла, дати основу для теплових двигунів, електростанцій, хімічних реакцій, холодильників; багато інших важливих концепцій, як працює мікроскопічний світ, формулювання чотирьох законів термодинаміки, механічний еквівалент тепла, внутрішня енергія системи, створити корисні системи, як працюють термодинамічні процеси, навпаки, сприяти, загальна внутрішня енергія системи, повністю перетворюватися на тепло, порушувати закони ентропії, хаотичний рух частинок, мати власні відмінні властивості, впливати на систему.

Exercise 3. Match the sentences

1. Heat is defined	a) to the heat acquired from the high temperature reservoir.

2. Work is the transfer of energy between two systems	b) but requires an ‘agent’ to apply a force through a distance to generate the work.
3. Reversible work	c) and delivers it to a hot reservoir by doing work.
4. Work does not occur spontaneously,	d) by all means other than a difference in temperature.
5. Joule did such an experiment	e) carries no entropy.
6. The Carnot efficiency of the heat engine is the ratio of the work performed	f) as the transfer of energy by virtue of a difference in temperature between two systems.
7. The refrigerator is a heat engine run in reverse. It “lifts” heat from a cold reservoir	g) when he measured the mechanical equivalent of heat.
8. Two systems are in thermal equilibrium	h) to absolute zero (T = 0 K) in a finite number of steps.
9. The first law of thermodynamics is the conservation-of-energy principle	i) to make heat (magnitude = $\|Q_C\|$) flow from a lower Kelvin temperature T_C to a higher Kelvin temperature T_H.
10. A thermal process is quasi-static when it occurs slowly enough	j) if there is no net flow of heat between them when they are brought into thermal contact.
11. Refrigerators, air conditioners, and heat pumps are devices that utilize work (magnitude = |W|)	k) applied to heat, work, and the change in the internal energy.
12. The third law of thermodynamics states that it is not possible to lower the temperature of any system	l) that a uniform pressure and temperature exist throughout the system at all times.

Exercise 4. Translate the following sentences into English

1. Енергія є одним з найбільш фундаментальних і універсальних концепцій фізичної науки.
2. Кінетична енергія пов'язана з рухом об'єкта, кількісно тіло з масою m і рухається зі швидкістю v володіє кінетичною енергією $mv^{2}/2$.
3. Потенційна енергія - це енергія, яку тіло має в силу свого розташування.
4. Кінетична енергія макроскопічних об'єктів може передаватися між об'єктами (виключаючи наслідки тертя).
5. Після того, як кінетична енергія стає термічною, тільки частина її може бути перетворена назад в потенційну енергію або бути зосереджена назад в кінетичну енергію макроскопічної.
6. Це обмеження, яке не має нічого спільного з технологією, але є фундаментальною властивістю природи, є предметом другого закону термодинаміки.
7. Перетворення тепла в роботу здійснюється за допомогою теплового двигуна, найпоширенішим прикладом якого є звичайний бензиновий двигун.
8. Робота, як і енергія, може приймати різні форми, найбільш звичною є механічна і електрична.
9. Наука про термодинаміку розвивалася з необхідності розуміння обмежень парових теплових двигунів на початку індустріальної епохи.
10. Основний закон природи, Другий закон термодинаміки, стверджує, що повне перетворення тепла в роботу неможливо.

(From https://ukrayinska.libretexts.org/)

Exercise 5. Read the following interesting piece of information. Share your opinion with your classmates

Igloos are traditionally associated with the indigenous populations of the Arctic regions of Alaska, Canada, and Greenland, broadly called the Inuits**.** They are temporary shelters made by Inuits to be used as winter homes or for hunting expeditions.

The key to a warm igloo lies in choosing the right raw material; and there are only two raw materials abundantly available in the Arctic—snow and ice.

An igloo is made of compressed snow**.** Compact hardened snow is a great insulator of heat because snow is nothing but semi-frozen water with roughly 95% trapped air. The air molecules trapped between the tiny ice crystals create air pockets**,** which act as excellent insulators that prevent heat loss due to convection. Thus, snow is the perfect material with which to build a warm abode amidst the freezing Arctic environment.

Unlike snow, ice is basically frozen water and does not contain a lot of air pockets, which makes it a bad insulator. Thus, snow is preferred over ice for the construction of igloos.

The type of snow used is equally important. Freshly fallen snow is brittle and powdery and cannot be used to build a sturdy structure. Thus, igloos are made by cutting out hardened, compressed snow blocks from the ground.

(*https://www.labxchange.org/library/items/lb:LabXchange:1fff8483:html:1#:~:text=An%20igloo%20is%20made%20of,heat%20loss%20due%20to%20convection*.)

Speaking

- Speak about transformation of heat into work.
- Speak about conduction, convection, radiation.
- Speak about energy units.

Unit 8.

I. Read and translate the text. Learn the new vocabulary

Atomic structure of matter

The history of atomic structure and quantum mechanics dates back to the times of Democritus, the person who first proposed that matter is composed of atoms. The study of the structure of an atom gives a great insight into the entire class of chemical reactions, bonds and their physical properties. The first scientific theory of atomic structure was proposed by John Dalton in the 1800s.

The English chemist John Dalton suggested that all matter is made up of atoms, which were indivisible and indestructible. He also stated that all the atoms of an element were exactly the same, but the atoms of different elements differ in size and mass.

Chemical reactions, according to Dalton's atomic theory, involve a rearrangement of atoms to form products. According to the postulates proposed by Dalton, the atomic structure comprises atoms, the smallest particle responsible for the chemical reactions to occur.

Matter cannot be separated individually, but it is an arrangement of several atoms. Atoms are the smallest unit of matter that is having protons, neutrons, and electrons and cannot be divided. The arrangement of numerous atoms decides the size, shape, and color of matter.

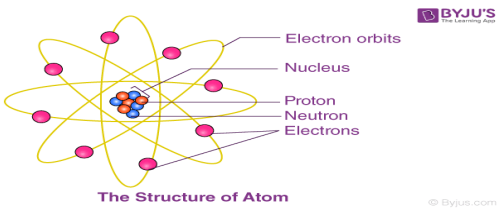

Fig.1. The atomic structure of matter

(From https: //byjus.com/jee/atomic-structure/)

Matter can either be a pure substance or a mixture. Pure substances can either be elements or compounds. Mixtures can either be homogeneous or heterogeneous.

An element is matter made of only one kind of atom. There are 115 known elements. Ninety elements are naturally occurring. The elements are organized according to their properties in the Periodic Table. For example, Hydrogen, Carbon, Nitrogen, Calcium, Sodium, Oxygen.

Compounds are two or more elements that are chemically combined. Compounds cannot be easily separated into their elements. For example, H2O Water, NaCl Salt, C6H12O6 Sugar]Glucose H2 N2 O2. The gases of hydrogen, nitrogen and oxygen naturally exist as compounds of two atoms of their element.

Mixtures are made of different compounds that are mixed together. Mixtures can be easily separated into the original compounds. Homogeneous – substances evenly mixed, heterogeneous – substances not evenly mixed.

Atoms interact through the electromagnetic force and create molecules. Molecules can include atoms of the same or different elements. Each type of molecule has its own properties which also define how it reacts with other molecules. The use and role of each type of molecules in nature is based on its properties.

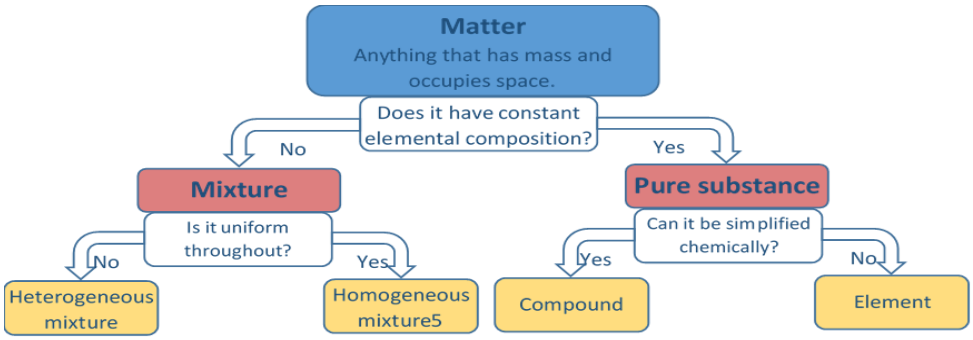

Fig.2. The structure of matter

(From https://ukrayinska.libretexts.org)

Physical properties of matter can be observed and measured without changing the kind of matter being studied. These physical properties can be used to identify a substance; i.e. melting point, boiling point, density (heaviness), color, ph.

Chemical properties of matter are not usually visible and, a change in the matter does occur. Chemical properties can also help identify a substance. Chemical properties can only be seen when there is a chemical reaction like burning, rusting, chemical reactivity.

The three classical states, solid, liquid, and gas of matter, can be distinguished macroscopically in terms of the properties of density, compressibility, and rigidity related to the motion of atoms or molecules. What are elements in structure of matter? All matter is made up of substances called elements, which have specific chemical and physical properties and cannot be broken down into other substances through ordinary chemical reactions.

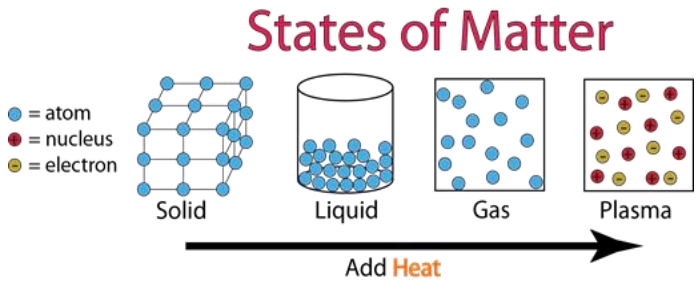

Fig.3. The four states of matter at the molecular level

(From https://www.hiclipart.com/free-transparent-background-png-clipart-mwpjm/download)

Primarily, the atomic structure of matter is made up of protons, electrons and neutrons. The protons and neutrons make up the nucleus of the atom, which is surrounded by the electrons belonging to the atom. The atomic number of an element describes the total number of protons in its nucleus.

Any characteristic that can be measured, such as an object's density, colour, mass, volume, length, malleability, melting point, hardness, odour, temperature, and more, are considered properties of matter. Chemical reactions are the processes through which atoms and]or molecules interact and are combined. There are different types of chemical reactions but they are mainly categorized depending on whether the system releases or absorbs energy.

(From https: //www.uomus.edu.iqimglectures21MUCLecture_2022_123047822.pdf)

Vocabulary

matter [ˈmætə(r)]	матерія
to be composed of	складатися з
insight [ˈɪn.saɪt]	в поле зору
entire [ɪnˈtaɪə(r)]	цілий
bond [bɒnd]	зв'язь
indivisible [ˌɪn.dɪˈvɪz.ɪ.bl̩]	неподільний
indestructible [ˌɪn.dɪˈstrʌk.tɪ.bl̩]	непорушний
postulate [ˈpɒs.tjʊ.leɪt]	постулат
to occur [əˈkɜː(r)]	відбуватися
substance [ˈsʌbstəns]	речовина
homogeneous [ˌhɒm.əˈdʒiː.ni.əs]	однорідний
heterogeneous [ˌhet.ər.əˈdʒiː.ni.əs]	неоднорідний
the periodic table	таблиця Менделєєва

hydrogen [ˈhaɪ.drɪ.dʒən]	водень
carbon [ˈkɑː.bən]	вуглець
nitrogen [ˈnaɪ.trə.dʒən]	азот
compound [ˈkɒm.paʊnd]	сполука
evenly [ˈiː.vən.li]	рівномірно
density [ˈden.sɪ.ti]	щільність
ph [ˌpiːˈeɪtʃ]	пі аш; рівень кислотності
rust [rʌst]	іржа
compressibility [kəmpresɪˈbɪlɪtɪ]	стисливість
rigidity [rɪˈdʒɪd.ɪ.ti]	жорсткість
malleability [ˌmæl.i.əˈbɪl.ɪ.ti]	пластичність
odour [ˈəʊ.dər]	запах

Exercise 1. Answer the following questions

1. What did Democritus propose? 2. What does the study of the structure of an atom give? 3. Who was the first scientific theory of atomic structure proposed by? 4. What did the English chemist John Dalton suggest? What did he state? 5. What do chemical reactions involve according to Dalton's atomic theory? 6. What is matter? 7. What are the smallest units of matter? 8. What decides the size, shape, and color of matter? 9. What can matter be? 10. What can pure substances be? 11. What can mixtures be? 12. What is an element? 13. How are elements organized? 14. What are compounds? Give examples. 15. What are mixtures made of? 16. How do atoms

interact? 17. What can you say about types of molecules? 18. How can physical properties of matter be observed? 19. What can you say about chemical properties of matter? 20. What are the three classical states of matter? 21. What is all matter made up of? 22. What does the atomic number of an element describe? 23. What are the properties of matter? 24. What are chemical reactions? 25. How can chemical reactions be categorized?

Exercise 2. Find the English equivalents in the text

історія атомної структури, квантова механіка, сходить до, дати велике розуміння, фізичні властивості, перша наукова теорія, відрізнятися за розміром і масою, найменша частинка, чиста речовина або суміш, може бути однорідною або неоднорідною, бути організованими відповідно до їхніх властивостей, бути хімічно поєднаними, рівномірно змішані речовини, взаємодіяти через електромагнітну силу, можна спостерігати та вимірювати, ідентифікувати речовину, хімічна реакція, тверда, рідка та газоподібна речовина; розпадатися на інші речовини, складатися з протонів, електронів і нейтронів; ядро, в основному класифікуватися залежно від, вивільняти або поглинати енергію.

Exercise 3. Match the sentences

1. At the most fundamental level, matter is composed of elementary particles known	a) astronomical observations that began in the 1930s and that show that a large fraction of the universe consists of “dark matter.”
2. Quarks combine into protons and neutrons and,	b) whose roots go back to Max Planck’s explanation in 1900 of the properties of electromagnetic radiation emitted by a hot body.

3. Depending on temperature and other conditions,

c) prevents a material body from responding instantaneously to attempts to change its state of rest or motion.

4. At ordinary temperatures, for instance, gold is a solid, water is a liquid, and nitrogen is a gas, as defined by certain characteristics:

d) the particles annihilate each other.

5. However, all matter of any type shares the fundamental property of inertia, which—as formulated within Isaac Newton's three laws of motion—

e) scientists finally announced in 2012 the discovery of the Higgs boson.

6. Another universal property

f) matter may appear in any of several states.

7. Einstein's theory of special relativity (1905) shows that matter (as mass) and energy

g) is gravitational mass, whereby every physical entity in the universe acts so as to attract every other one, as first stated by Newton and later refined into a new conceptual form by Albert Einstein.

8. The concept of matter is further complicated by quantum mechanics,

h) an elementary subatomic particle known as the Higgs boson imparts mass to all known elementary particles.

9. Additional complexity in the meaning of matter comes from

i) solids hold their shape, liquids take on the shape of the container that holds them, and gases fill an entire container.

	These states can be further categorized into subgroups.
10. Although a fully satisfactory grand unified theory (GUT) has yet to be derived, one component, the electroweak theory of Sheldon Glashow, Abdus Salam, and Steven Weinberg (who shared the 1979 Nobel Prize for Physics for this work) predicted that	j) can be converted into each other according to the famous equation $E = mc^2$, where E is energy, m is mass, and c is the speed of light.
11. After years of experiments using the most powerful particle accelerators available,	k) along with electrons, form atoms of the elements of the periodic table, such as hydrogen, oxygen, and iron.
12. When matter meets antimatter,	l) as quarks and leptons (the class of elementary particles that includes electrons).

Exercise 4. Translate the following sentences into English

1. Матерія складається з крихітних частинок, які називаються атомами, що утримуються разом силами, званими зв'язками.

2. Матерія класифікується як чиста речовина, якщо вона має постійний і незмінний склад типу атомів. Наша матерія - це або елемент, або з'єднання.

3. Традиційно у фізичній картині світу виділяють два фундаментальні види матерії — речовину та фізичні поля.

4. Однак, такий поділ є умовним, оскільки в рамках квантової теорії поля будь-яка частинка описується квантованим фізичним полем.

5. Останніми роками для пояснення прискорення розширення Всесвіту, про що свідчать астрономічні спостереження, виникла необхідність гіпотезувати існування нового виду матерії, яка отримала назву темної енергії.

6. Природа темної енергії залишається нез'ясованою.

7. Нейтронна речовина — складається переважно з нейтронів і позбавлена атомної будови.

8. За сучасними уявленнями квантове поле є універсальною формою матерії,

9. Класична речовина може перебувати в одному з декількох агрегатних станів: газоподібний, рідкий, твердий кристалічний, твердий аморфний або у вигляді рідкого кристала.

10. Елементи представлені символами, першим алфавітом їх англійської або неанглійської назви, написаним великими літерами. Наприклад, C — для вуглецю, O —для кисню, а H — для водню.

(From https://uk.wikipedia.org/wiki/Матерія_(фізика); https://ukrayinska.libretexts.org/)

Exercise 5. Read the following interesting pieces of information. Share your opinion with your classmates

- Oxygen is made up of a single atom.
- Pure liquid helium can be converted into solid by heating at -272c.
- Compound gases like CO2 are made up of more than two particles.
- A vacuum is an area containing no matter.
- Plasma can be found in polar auroras.
- The volume of gas is not constant.
- 97% of the water present on earth is salt water. When water freezes, it expands up to 9%.

(https://www.quora.com/Is-oxygen-an-atom-or-element)

Speaking

- Speak about the atomic structure of matter.
- Speak about states of matter.
- Speak about matter and energy.

Unit 9.

I. Read and translate the text. Learn the new vocabulary

Waves

A wave is just the propagation or storage of energy through a medium or the vacuum, without any transfer of the medium itself. Travelling waves transfer energy from one point to another through a vacuum or a medium. Standing waves do not transfer energy, but instead store energy in the medium or vacuum. A wave can reflect, refract, diffract, exhibit interference, and in the case of transverse waves, can be polarised.

There are many ways to categorise waves: electromagnetic waves, mechanical waves, progressive waves, standing waves, transverse, longitudinal, polarised, unpolarised, etc.

The speed of a wave (v) is related to its wavelength (λ) and frequency (f) by

$$v=f\lambda$$

Waves are defined by their wavelength and frequency.

Wavelength (λ) is the distance over which the shape of the wave repeats at a given time.

Frequency (*f*) is the number of times the wave shape repeats per unit time at a given point. The inverse of the frequency is the **period** (*T*), where $T=f1$.

Period (*T*) is the time for it takes for the wave to repeat itself at a given point.

The **wave speed** (*v*) is the speed at which wave propagates, or the speed at which a point of fixed phase moves forwards, or at which the wave fronts move. It is perhaps easiest to visualise wavefronts in the case of water waves, as lines joining points where the water has the same height. The wave speed is related to frequency and wavelength by $v=f\lambda$ which is known as the wave equation.

Another important characteristic of a wave is its **amplitude** (*A*), the maximum displacement of the wave from its undisturbed position.

The **intensity** of a wave is the average energy transferred through a unit area in unit time. The energy of the wave is proportional to the square of its amplitude and so is its intensity.

Waves can be categorised as either longitudinal or transverse. These depend on the directions of the oscillation and the direction of propagation of the wave.

In **transverse** waves, the direction of oscillation is perpendicular to the direction of propagation. This is the case for waves on strings, water waves in certain conditions and light waves.

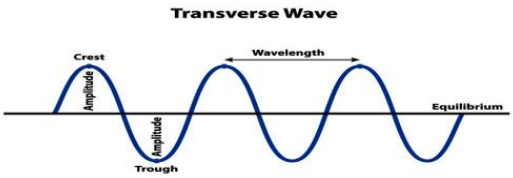

Fig1. Transverse wave

(From https://www.google.com/search?q=transverse+waves+picture)

In **longitudinal** waves, the direction of oscillation is parallel to the direction of propagation. This causes a series of compressions (regions where the particles are closer together than in their undisturbed state) and rarefactions (regions where the particles are further apart than in their undisturbed state) in the medium the wave travels through. Sound waves and some seismic waves are longitudinal.

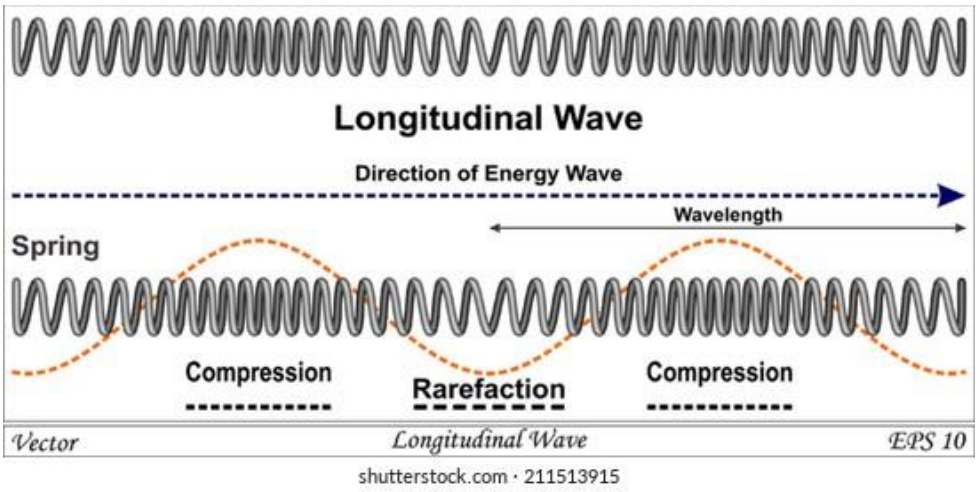

Fig.2 Longitudinal wave

(*From https://www.google.com/search?q=transverse+waves+picture)*

The phase of a point on a wave relative to the origin can be defined as the fraction of the wave cycle that has elapsed since the origin. The phase of a wave can be represented by an angle, ϕ, with $\phi = 2\pi \text{rad} = 360\circ$ being equivalent to a full cycle.

It is possible to determine the phase difference ($\Delta\phi$) between two different waves, as it affects the resultant wave when the two interact with each other.

Two waves that are at the same point on their wave cycles at the same time are said to be in phase.

Matter and particles with mass can exhibit wavelike properties; for example electrons can diffract in the same way as light in the double slit experiment.

A photon has no mass. However, it does have a momentum. The momentum of a photon cannot be calculated in the usual way, but is instead found using de Broglie's relation.

(From https://isaacphysics.org/concepts/cp_general_waves?stage=all)

Vocabulary

propagation [ˌprɒp.əˈgeɪ.ʃən]	поширення
medium [ˈmiː.di.əm]	середовище
refract [rɪˈfrækt]	заломлювати
to exhibit [ɪgˈzɪb.ɪt]	демонструвати
interference [ˌɪn.təˈfɪə.rəns]	втручання
transverse waves [trænzˈvɜːs weɪvz]	поперечні хвилі
longitudinal [ˌlɒŋ.gɪˈtʃuː.dɪ.nəl] UK[ˌlɒn.dʒɪˈtʃuː.dɪ.nəl]	поздовжній
inverse [ɪnˈvɜːs]	зворотний
the wave front	хвильова поверхня
displacement [dɪˈspleɪs.mənt]	переміщення
oscillation [ˌɒs.ɪˈleɪ.ʃən]	коливання
rarefaction ['re(ə)rɪ'fækʃ(ə)n]	розрідження
fraction [ˈfræk.ʃən]	дріб, частина
to diffract [dɪˈfrækt]	дифрагувати

a momentum [məˈmen.təm] імпульс

Exercise 1. Answer the following questions

1. What is a wave? 2. What do travelling waves do? 3. Standing waves do not transfer energy, do they? 4. What can a wave do? 5. How can waves be categorized? 6. What is the formula that describes the speed of wave? 6. How are waves defined? 7. What is frequency? 8. What is the inverse of the frequency? 9. What is the wave speed? 10. What is known as the wave equation? 11. What is another important characteristic of a wave? 12. What is the intensity of a wave? 13. How can waves be categorized? 14. What can be said of transverse waves? 15. What is typical for longitudinal waves? 16. Are sound waves longitudinal? 17. How can the phase of a wave be represented? 18. When are the waves said to be in phase? 19. What can matter and particle exhibit? 20. What does a photon have? 21. How can the momentum of a photon be calculated?

Exercise 2. Find the English equivalents in the text

розповсюдження або накопичення енергії, через середовище чи вакуум, виявляти інтерференцію, поляризувати, класифікувати хвилі, швидкість хвилі, форма хвилі в даній точці, швидкість, з якою хвиля поширюється; хвильове рівняння, максимальне зміщення хвилі від її незбуреного положення, пропорційне квадрату її амплітуди, напрямки коливань і поширення хвилі, світлові хвилі, у їх незбуреному стані, сейсмічні хвилі, частка циклу хвилі, визначити різницю фаз, взаємодіяти один з одним, виявляти хвилеподібні властивості, в експерименті з подвійною щілиною, дифрагувати так само, як світло; відношення.

Exercise 3. Match the sentences

1. The word supersonic comes from two Latin derived words: 1) *super*: above and 2) *sonus*: sound,

a) rotates around its tail, which is pivoted at the origin of a coordinate system.

2. At the beginning of the 20th century, the term "supersonic" was used as an adjective to describe sound whose frequency is above the range of normal human hearing.

b) which together mean above sound, or faster than sound.

3. Supersonic speed is the speed of an object

c) is approximately 343.2 m]s (1,126 ft/s; 768 mph; 1,236 km/h).

4. For objects traveling in dry air of a temperature of 20 °C (68 °F) at sea level, this speed

d) perpendicularly to the wave's direction of travel (we are dealing with a transverse wave).

5. Speeds greater than five times the speed of sound (Mach 5)

e) in the form of pressure waves in an elastic medium.

6. Sounds are traveling vibrations

f) are often referred to as hypersonic.

7. In solids, sound waves can be polarized longitudinally or

g) motion of space shuttles.

8. Examples of supersonic waves are wave produced when the bullet is fired from a gun; wave produced by the motion of fighter planes and wave produced by the	h) when several effects occur simultaneously, their net effect is the sum of the individual effects.
9. As a wave passes through any element on a stretched string, the element moves	i) fall simultaneously on our eardrums.
10. When we listen to a concert, for example, sound waves from many instruments	j) that exceeds the speed of sound (Mach 1).
11. This is another example of the principle of superposition, which says that	k) The modern term for this meaning is "ultrasonic".
12. A phasor is a vector that	l) transversely and have even higher velocities.

Exercise 4. Translate the following sentences into English

1. Процес поширення коливань у просторі називають хвилею або хвильовим процесом.

2. Напрям поширення хвилі називають променем.

3. Залежно від напряму коливання частинок середовища щодо напряму поширення хвиль їх поділяють на поперечні і поздовжні.

4. Поперечними називають хвилі, у яких частинки коливаються в перпендикулярному до променя хвилі напрямі.

5. Хвилі, у яких частинки коливаються в напрямі їхнього поширення, називають поздовжніми.

6. Фізика вивчає різні за своєю природою хвилі: механічні, електромагнітні тощо.

7. Але під час опису хвилі мають досить багато спільного, а тому можуть бути вивчені на прикладі механічних хвиль.

8. Якщо взаємодія між частинками середовища здійснюється від передавання коливань від одних частинок до інших, то такі частинки називаються пружними (звукові, ультразвукові, сейсмічні).

9. Під час поширення хвилі в певному середовищі може спостерігатися її відхилення від прямолінійного поширення, а також посилення чи послаблення в певних точках середовища.

10. Перше явище називається дифракцією, друге – інтерференцією. Ці явища характерні для всіх видів хвиль.

(From Шкурдода Ю. О. Фізика. Механіка, молекулярна фізика та термодинаміка : навчальний посібник] Ю. О. Шкурдода, О. О. Пасько, О. А. Коваленко. – Суми: Сумський державний університет, 2021. – С.121)

Exercise 5. Read the following interesting pieces of information. Share your opinion with your classmates

- Ocean waves can interact with each other and form more complex patterns, such as constructive and destructive interference.
- The idea of turning wave energy into electricity occurred in 1799 when Girard & Son patented a mechanism to drive wave power to activate pumps, mills, saws, and heavy machinery.
- Ocean waves help regulate global temperatures by transferring heat from the equator to the poles.

(*https://corpowerocean.com/history-of-wave-energy/*)

Speaking

- Speak about waves.
- Speak about supersonic waves.
- Speak about applications of sound in medicine.

Unit 10.

I. Read and translate the text. Learn the new vocabulary

Wave motion

Wave motion, propagation of disturbances—that is, deviations from a state of rest or equilibrium—from place to place in a regular and organized way. Most familiar are surface waves on water, but both sound and light travel as wavelike disturbances, and the motion of all subatomic particles exhibits wavelike properties. The study of waves therefore forms a topic of central importance in all physical science and engineering.

The simplest types of wave motion are vibrations of elastic media, such as air, crystalline solids, or stretched strings. If, for example, the surface of a metal block is struck a sharp blow, the deformation of the surface material compresses the metal in the vicinity of the surface, and this transmits the disturbance to the layers beneath. The surface relaxes back to its initial configuration, and the compression propagates on into the body of the material at a speed determined by the stiffness of the material. This is an example of a compression wave. The steady transmission of a localized disturbance through an elastic medium is common to many forms of wave motion.

In most systems of interest, two or more disturbances of small amplitude may be superimposed without modifying one another. Conversely, a complicated disturbance may be analyzed into several simple components. In radio transmission, for example, a high-frequency signal can be superimposed on a low-frequency carrier wave and then filtered out intact on reception.

In the simplest waves, the disturbance oscillates periodically with a fixed frequency and wavelength. These sinusoidal oscillations form the basis for the study of almost all forms of linear wave motion. In sound, for instance, a single sine wave produces a pure tone, and the distinctive timbre of different musical instruments playing the same note results from the admixture of sine waves of different frequencies. In electronics, the natural rhythmic oscillations of electric currents in tuned circuits are used to produce sinusoidal radio waves.

Although the mathematical properties of all linear waves are common, the waves exhibit various physical manifestations. One important class—electromagnetic waves—represents oscillations of the electromagnetic field. These include infrared radiation, visible light, radio and television, microwave, ultraviolet, X-rays, and gamma rays. Electromagnetic waves are produced by moving electric charges and varying currents, and they can travel through a vacuum. Unlike sound waves, they are not, therefore, disturbances in any medium. Another difference between electromagnetic and sound waves is that the former are transverse, that is, the disturbance occurs in a direction perpendicular to that in which the wave is propagating. Sound waves are longitudinal: they vibrate along the path of their propagation.

The propagation of a wave through a medium will depend on the properties of the medium. For example, waves of different frequencies may travel at different speeds, an effect known as dispersion. In the case of light, dispersion leads to the unscrambling of colours and is the mechanism whereby a prism of glass can produce a spectrum. In

geophysics, the dispersive propagation of seismic waves can provide information about the constitution of Earth's interior.

Two important characteristics of all waves are the phenomena of diffraction and interference. When a wave disturbance is directed toward a small aperture in a screen or other obstacle, it emerges traveling in a range of directions. Thus, light rays, which normally follow straight paths, can bend upon passing through a small hole: this is the phenomenon known as diffraction.

Interference occurs when two waves are combined and the disturbances overlap. If the waves arrive at a point in phase, enhancement occurs and the disturbance is large. Where the waves are out of phase, their opposing motions cancel and the disturbance is small or nonexistent. The net effect is therefore a distinctive interference pattern of large and small disturbances.

Mathematically less tractable is the study of nonlinear waves, which can be very important in many applications. These usually display a more complicated structure and behaviour; for example, water waves in a shallow channel can develop a humplike formation known as a soliton, which propagates as a coherent entity. Nonlinear waves are important in systems as diverse as nerve networks and the spiral arms of galaxies.

(From https://www.britannica.com/science/wave-motion)

Vocabulary

propagation [ˌprɒp.əˈgeɪ.ʃən]	поширення
deviation [ˌdiːviˈeɪʃn]	відхилення
equilibrium [ˌiː.kwɪˈlɪb.ri.əm]	рівновага

a subatomic particle_ [ˌsʌb.əˈtɒm.ɪk ˈpɑː.tɪ.kl̩]	субатомна частинка
central importance	важливе значення
wavelike properties	хвилеподібні властивості
exhibit [ɪgˈzɪbɪt]	проявляти
elastic media [ɪˈlæs.tɪk ˈmiːdiə]	еластичні середовища
crystalline solids_[ˈkrɪs.təl.aɪn ˈsɒl.ɪdz]	кристалічні тверді речовини
vicinity [vɪˈsɪn.ɪ.ti]	поблизу
layer [ˈleɪə(r)]	шар
stiffness of the material	жорсткість матеріалу
superimpose [ˌsuː.pə.rɪmˈpəʊz]	накладати
admixture [ədˈmɪks.tʃər]	домішка
longitudinal [ˌlɒŋ.gɪˈtʃuː.dɪ.nəl] [ˌlɒn.dʒɪˈtʃuː.dɪ.nəl]	поздовжній
dispersion [dɪˈspɜː.ʃən]	дисперсія
unscramble [ʌnˈskræm.bl̩]	розшифровувати
diffraction [dɪˈfræk.ʃən]	дифракція
interference [ˌɪn.təˈfɪə.rəns] pattern	інтерференційна картина
enhancement [ɪnˈhɑːnsmənt]	покращення
tractable [ˈtræk.tə.bl̩]	податливий

diverse [daɪˈvɜːs]	різноманітний
hump	горб, вершина кривої
soliton	солітон (одиночна хвиля)

Exercise 1. Answer the following questions

1. What is the propagation of disturbances? 2. What examples of wavelike disturbances do you know? 3. The motion of all subatomic particles exhibits wavelike properties, doesn't it? 4. Does the study of waves therefore form a topic of central importance in all physical science and engineering? 5. Are vibrations of elastic media the simplest types of wave motion or not? 6. Can you give any example of a compression wave? 7. Is the steady transmission of a localized disturbance through an elastic medium common to many forms of wave motion? 8. How can one explain that in radio transmission, for example, a high-frequency signal can be superimposed on a low-frequency carrier wave and then filtered out intact on reception? 9. In what waves does the disturbance oscillate periodically with a fixed frequency and wavelength? 10. What properties are common for all linear waves? 11. Why do linear waves exhibit various physical manifestations despite the fact that their mathematical properties are common?

Exercise 2. Find the English equivalents in the text

хвильовий рух, поширення збурень, стан спокою або рівноваги, рух усіх субатомних частинок, тема центрального значення, фізична наука та техніка, коливання пружних середовищ, початкова конфігурація, поширюється всередину тіла матеріалу, а хвиля стиснення, високочастотний сигнал, який накладається на низькочастотну несучу хвилю; збурення періодично коливається, синусоїдальні коливання, одна синусоїда, математичні властивості всіх лінійних хвиль,

інфрачервоне випромінювання, електричні заряди та змінні струми, поздовжні, вібрувати вздовж шляху їх поширення, залежати від властивостей середовища, рухатися з різними швидкостями, створювати спектр, надавати інформацію про будову надр Землі, явища дифракції та інтерференції, можуть згинатися при проходженні через невеликий отвір, збурення накладаються, менш піддаються математичному розгляду, нелінійні хвилі.

Exercise 3. Match the sentences

1. All bodies, no matter how hot or cold,	a) is an essential characteristic of waves.
2. At a given temperature, the intensities of the electromagnetic waves emitted by an object	b) is that particles can also behave like waves and exhibit interference effects.
3. In 1900 Planck calculated the blackbody radiation curves, using a model	c) whose masses are very small, on the order of the mass of an electron or a neutron, for instance.
4. The ability to exhibit interference effects	d) has a wavelength associated with it, just as a wave does.
5. One of the most incredible discoveries of twentieth-century physics	e) vary from wavelength to wavelength throughout the visible, infrared, and other regions of the spectrum.
6. For the moment, we intend only to emphasize that the concept of an	f) can exhibit wave-like characteristics.

electron as a tiny discrete particle of matter

7. Waves can exhibit particle-like characteristics, and particles

g) does not account for the fact that the electron can behave as a wave in some circumstances.

8. All electromagnetic radiation

h) that represents a blackbody as a large number of atomic oscillators, each of which emits and absorbs electromagnetic waves.

9. A photon has no mass and always

i) consists of photons, which are packets of energy.

10. As a graduate student in 1923, Louis de Broglie (1892–1987) made the astounding suggestion that since light waves could exhibit particle-like behavior,

j) travels at the speed of light in a vacuum.

11. De Broglie proposed that all moving matter

k) particles of matter should exhibit wave-like behavior.

12. Although all moving particles have a de Broglie wavelength, the effects of this wavelength are observable only for particles

l) continuously radiate electromagnetic waves.

Exercise 4. Translate the following sentences into English

1. Поширення збурень у просторі з плином часу називається хвильовим процесом, або просто хвилею.

2. Одним з класифікаторів хвилі є напрям коливань, що відбуваються в ній. За цією ознакою хвилі поділяють на поздовжні та поперечні.

3. В поздовжній хвилі коливання в кожній точці відбуваються вздовж напрямку поширення.

4. В поперечній хвилі коливання відбуваються перпендикулярно до напрямку поширення.

5. Електромагнітні хвилі можуть існувати і в речовині, й у вакуумі, і завжди є поперечними.

6. Натомість механічні хвилі, котрі є можливі тільки в речовині, можуть бути як поперечними, так і поздовжніми.

7. При цьому тип хвиль, які можуть виникати, залежить від взаємодії між молекулами середовища.

8. Довжина хвилі дорівнює відстані, на яку поширюється хвиля за час одного періоду коливань.

9. За Максвелом, змінне електромагнітне поле існує у формі електромагнітних хвиль.

10. У дійсності електромагнітна енергія переноситься не неперервною хвилею, а потоком особливих елементарних частинок — квантів, які мають і хвильові, і корпускулярні властивості.

(From http://physics.zfftt.kpi.ua/mod/book/view.php?id=299&chapterid=57)

Exercise 5. Read the following interesting pieces of information. Share your opinion with your classmates

The largest wave ever recorded by humans measured 1,720 feet. It was triggered by an earthquake that hit Alaska's Lituya Bay on July 9, 1958. It was the result of an earthquake that hit Alaska's Lituya Bay on July 9, 1958. Two occupants of a small fishing boat surfed that wave and survived to tell the story.

Most waves we see coming in from the horizon are a product of wind blowing over large ocean areas.

The typical length of tsunami waves is about 100 times the depth.

(*https://www.surfertoday.com/surfing/interesting-facts-about-waves*)

Speaking

- Speak about wave propagation.
- Speak about different types and features of waves.
- Speak about James Clerk Maxwell, Thomas Young, Hendrik Antoon Lorentz.

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3. Шкурдода Ю. О. Фізика. Механіка, молекулярна фізика та термодинаміка: навчальний посібник / Ю. О. Шкурдода, О. О. Пасько, О. А. Коваленко. – Суми: Сумський державний університет, 2021. – С.121.

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ДЛЯ НОТАТОК

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Навчальне видання

ENGLISH FOR STUDENTS OF PHYSICS AND ASTRONOMY (PART 1. MECHANICS, THERMODYNAMICS AND MOLECULAR PHYSICS)

МЕТОДИЧНІ ВКАЗІВКИ

до практичних занять
з навчальної дисципліни ««Іноземна мова (за професійним спрямуванням)» для здобувачів першого (бакалаврського) рівня вищої освіти спеціальності 104 «Фізика та астрономія»

Укладач
Кузнєцова Галина Петрівна

В авторській редакції

Підписано до друку 28.06.2024 р. Формат 60х84/16.
Папір офсетний. Гарнітура Times. Цифровий друк.
Ум. друк. арк. 5,35. Наклад 30. Зам. № 0824-15.
Віддруковано з готового оригінал-макета.

Видавництво та друк: Олді+
65101, Україна, м. Одеса, вул. Інглезі, 6/1
Свідоцтво ДК № 7642 від 29.07.2022 р.

Тел.: +38 (098) 559-45-45,
+38 (095) 559-45-45, +38 (093) 559-45-45
Для листування: 65101, Україна, м. Одеса, вул. Інглезі, 6/1
E-mail: office@oldiplus.ua