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**English for
Specific Purposes.
PHYSICS**



Міністерство освіти і науки України
Чернівецький національний університет імені Юрія Федьковича

ENGLISH FOR SPECIFIC PURPOSES. PHYSICS

Навчальний посібник з англійської мови
для студентів фізико-технічних спеціальностей
вищих навчальних закладів

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Навчальний посібник спрямований на розвиток та вдосконалення усної та письмової англійської мови за професійним спрямуванням. Призначений для студентів фізико-технічних спеціальностей, а також усіх, хто цікавиться фізикою, прагне удосконалити набуті знання та розширити словниковий запас англійською фізичною термінологією. Посібник містить об'ємний текстово-інформаційний матеріал тематичного характеру із вправами для закріплення матеріалу та англійський словник фізичних термінів для розвитку мовленнєвих навичок.

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UNIT I

THE STUDY OF PHYSICS

What is Physics?

1. a) Read and translate the text into Ukrainian using the dictionary and paying attention to the underlined words and word combinations.

Physics is a natural science that studies matter, energy and the fundamental forces of nature. It helps us understand how the world around us works, from the smallest particles to the vast universe. In the broadest sense, physics is concerned with all aspects of nature on both the macroscopic and submicroscopic levels. Its scope of study encompasses not only the behaviour of objects under the action of given forces but also the nature and origin of gravitational, electromagnetic, and nuclear force fields. Its ultimate objective is the formulation of a few comprehensive principles that bring together and explain all such disparate phenomena. Physics explains why the sky is blue, how electricity flows, and even how planets move in space. It is one of the oldest sciences and plays a crucial role in modern technology.

The word *physics* comes from the Latin *physica* ('study of nature'), which itself is a borrowing of the Greek *φυσική* (*phusikḗ* 'natural science'), a term derived from *φύσις* (*phúsis* 'origin, nature, property').

Physics covers a wide range of phenomena, from elementary particles (such as quarks, neutrinos and electrons) to the largest superclusters of galaxies. Included in these phenomena are the most basic objects composing all other things. Therefore, physics is sometimes called the "fundamental science". Physics aims to describe the various phenomena that occur in nature in terms of simpler phenomena. Thus, physics

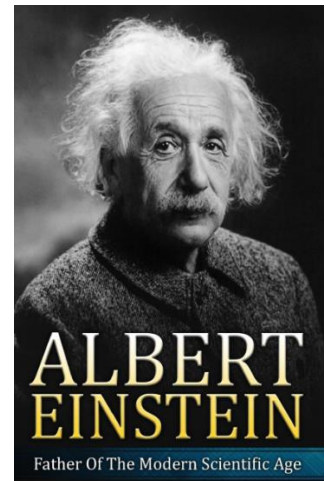
aims to both connect the things observable to humans to root causes, and then connect these causes together.

Physics is the basic physical science. Until rather recent times physics and natural philosophy were used interchangeably for the science whose aim is the discovery and formulation of the fundamental laws of nature. As the modern sciences developed and became increasingly specialized, physics came to denote that part of physical science not included in astronomy, chemistry, geology, and engineering. Physics plays an important role in all the natural sciences, however, and all such fields have branches in which physical laws and measurements receive special emphasis, bearing such names as astrophysics, geophysics, biophysics, and even psychophysics. Physics can, at base, be defined as the science of matter, motion, and energy. Its laws are typically expressed with economy and precision in the language of mathematics.

Modern physics began in the early 20th century with the work of Max Planck in



quantum theory and Albert Einstein's theory of relativity. Both of these theories came about due to inaccuracies in classical mechanics in certain situations. Classical



mechanics predicted that the speed of light depends on the motion of the observer, which could not be resolved with the constant speed predicted by Maxwell's equations of electromagnetism. This discrepancy was corrected by Einstein's theory of special relativity, which replaced classical mechanics for fast-moving bodies and allowed for a constant speed of light. Black-body radiation provided another problem for classical physics, which was corrected when Planck proposed that the excitation of material oscillators is possible only in discrete steps proportional to their frequency. This, along with the photoelectric effect and a complete theory predicting discrete energy levels of electron orbitals, led to the theory of quantum mechanics improving on classical physics at very small scales.

Importance of Physics

Physics is important in many fields, including engineering, medicine and environmental science. It helps scientists develop new materials, improve medical technology and understand climate change. Without physics, we would not have computers, smartphones, airplanes or even modern transportation.

Advances in physics often enable new technologies. For example, advances in the understanding of electromagnetism, solid-state physics and nuclear physics led directly to the development of technologies that have transformed modern society, such as television, computers, domestic appliances, and nuclear weapons; advances in thermodynamics led to the development of industrialization; and advances in mechanics inspired the development of calculus.

Everyday Applications

Even in daily life, physics is everywhere. When we drive a car, use a smartphone, or cook food, we apply the principles of physics. Engineers use physics to design strong buildings and bridges, while doctors use physics to create medical imaging techniques like X-rays and MRIsⁱ.

Studying Physics

Learning physics requires curiosity, logical thinking and problem-solving skills. Scientists or students study theories, conduct experiments and apply mathematical formulas to explain natural phenomena. While physics can be challenging, it is also fascinating and rewarding because it helps us understand the universe better.

In conclusion, physics is a fundamental science that explains the laws of nature. It influences technology, daily life and scientific discoveries. By studying physics, we gain knowledge that helps us create a better future.

ⁱ *MRIs – magnetic resonance imaging: a system for producing electronic pictures of the organs inside a person's body, using radio waves and a strong magnetic field.*

b) Translate the italicized paragraph into Ukrainian (in writing).

c) Put 5 questions to the text.

2. Remember a synonymous series for different words from the text.

1. *Physics* – natural science, fundamental science, physical science.

2. *Matter* – substance, material, physical entity.

3. *Energy* – power, force, vitality.

4. *Fundamental* – essential, basic, primary, core.

5. *Scope* – range, extent, area, field.

6. *Behaviour* – actions, conduct, movement, response.

7. *Phenomena* – events, occurrences, happenings, processes.

8. *Explain* – clarify, describe, interpret, define.

9. *Ultimate* – final, supreme, highest, definitive.

10. *Origin* – source, beginning, foundation, cause.

11. *Object* – goal, aim, purpose, target.

12. *Role* – function, purpose, responsibility, significance.

13. *Technology* – innovation, advancement, machinery, engineering.

14. *Discovery* – finding, breakthrough, invention, revelation.

15. *Influence* – impact, effect, significance, contribution.

16. *Theory* – concept, hypothesis, framework, principle.

17. *Classical* – traditional, conventional, established, historical.

18. *Mechanics* – dynamics, physics of motion, kinematics.

19. *Develop* – create, advance, improve, innovate.

20. *Applications* – uses, functions, implementations, practical uses.

a) **Choose the correct synonym. Each sentence contains a word that can be replaced with a synonym from the given list. Replace the word in bold so that the meaning of the sentence remains the same.**

1. The **goal** of physics is to describe natural phenomena in simple terms.
2. Scientists made many important **findings** in the 20th century.
3. The **extent** of physics includes everything from small particles to galaxies.
4. The **source** of energy in stars is nuclear fusion.
5. Engineers use physics for the **creation** of modern technologies.
6. Quantum mechanics was developed due to **difficulties** in classical physics.
7. Many scientific **concepts** were first just theories.
8. Physics has a strong **impact** on modern society.
9. Studying physics can be **challenging**, but it is also very rewarding.
10. Scientists work to **improve** medical technology using physics.

3. **Using the dictionary transcribe and translate the key words and words combinations:**

<i>Word</i>	<i>Transcription</i>	<i>Translation</i>
elementary particles		
quark		
neutrino		
electron		
to encompass		
Maxwell's equation		
black-body radiation		
due to inaccuracies		

solid-state physics		
Einstein's theory of special relativity		
frequency		
a constant speed of light		
the motion of the observer		
oscillator		
discrepancy		
discrete steps		
fast-moving body		
photoelectric effect		
nuclear force		

4. Match the words with their definitions:

- 1) Physics – ____
- 2) Matter – ____
- 3) Energy – ____
- 4) Quantum mechanics – ____
- 5) Electromagnetism – ____
- 6) Relativity – ____
- 7) Thermodynamics – ____
- 8) Technology – ____
- 9) Mechanics – ____
- 10) Experiment – ____

a) The science that explains the laws of nature, studying matter, energy, and fundamental forces.

- b) Anything that has mass and takes up space.
- c) The ability to do work or cause change.
- d) A field of physics that describes the behavior of particles on a very small scale, such as electrons and photons.
- e) The study of electric and magnetic fields and their interactions.
- f) A theory developed by Albert Einstein that explains the relationship between space, time, and gravity.
- g) The study of heat, work, and energy transfer in systems.
- h) The application of scientific knowledge to create tools, machines, and innovations that improve life.
- i) The branch of physics that deals with the motion of objects and forces acting upon them.
- j) A scientific process in which observations and measurements are made to test a hypothesis.

5. Give English equivalents to the meanings of the following words and word combinations.

Речовина	
Енергія	
Квантова механіка	
Електромагнетизм	
Термодинаміка	
Теорія відносності	
Передові технології	
Постійна швидкість	
Рух спостереження	
Фізика твердого тіла	

Матерія	
Магнетизм	
Практичне застосування науки	

6. Find synonyms to the words and word combinations.

Science, substance, power, small-scale physics, electricity and magnetism, theory of space-time, heat transfer science, innovation, study of motion, scientific text, fundamental knowledge, physical world, discovery, modern devices, logical thinking, technological progress, wave-particle duality, energy transformation, gravitational theory, practical application of science.

7. Choose the correct answer:

- What does physics study?
 - Heat transfer science.
 - Matter, energy, and fundamental forces.
 - Fundamental knowledge.
 - Human psychology.
- Why is physics called the "fundamental science"?
 - It explains natural phenomena using simpler concepts.
 - It was the first science to be discovered.
 - It only studies microscopic particles.
 - It focuses only on theoretical models.
- Which scientist developed the theory of relativity?
 - Isaac Newton.
 - Niels Bohr.
 - Albert Einstein.
 - James Clerk Maxwell.
- Which branch of physics deals with the behavior of particles on a very small scale?

- A) Thermodynamics.
 - B) Electromagnetism.
 - C) Quantum mechanics.
 - D) Classical mechanics.
5. What did Max Planck contribute to modern physics?
- A) The theory of evolution.
 - B) The concept of discrete energy levels (quantum theory).
 - C) The laws of motion.
 - D) The discovery of electricity.
6. Which of the following is an everyday application of physics?
- A) Cooking food.
 - B) Observations and measurements.
 - C) Relationship between space, time, and gravity.
 - D) Energy transfer in systems.
7. What problem in classical physics led to the development of quantum mechanics?
- A) The incorrect prediction of black-body radiation.
 - B) The inability to explain human emotions.
 - C) The lack of understanding of chemical reactions.
 - D) The failure to describe the speed of sound.
8. How does physics help in medicine?
- A) By developing medical imaging techniques like X-rays and MRIs.
 - B) By writing medical textbooks.
 - C) By designing better hospital uniforms.
 - D) By creating new food recipes.
9. Why is studying physics important?
- A) It helps us understand the universe and develop new technologies.
 - B) It only teaches us about stars and planets.
 - C) It is useful only for scientists.

D) It helps people learn foreign languages.

10. Which major physics theory explains the motion of fast-moving objects and the nature of space-time?

A) Classical mechanics.

B) Special relativity.

C) Thermodynamics.

D) Quantum mechanics.

11. Which of the following is the best way to translate the sentence?

Physics plays an important role in the development of new technologies.

A) Фізика відіграє важливу роль у розвитку нових технологій.

B) Фізика досліджує важливу роль нових технологій.

C) Фізика взаємодіє із розвитком нових важливих технологій.

D) Фізика займається вивченням нових важливих технологій.

12. The word combination *a constant speed of light* in the text is translated into Ukrainian as

A) стала швидкість світла.

B) швидкість світла.

C) непостійна швидкість світла.

D) фізична швидкість світла.

8. Translate the following sentences into Ukrainian:

1. Without physics, we would not have airplanes, electricity, or modern transportation.

2. Advances in physics have led to the development of computers, smartphones, and medical imaging technologies.

3. Classical mechanics could not explain the constant speed of light, which led to the creation of special relativity.

4. Quantum mechanics explains the behavior of very small particles like electrons and photons.

5. Albert Einstein developed the theory of relativity, which changed our understanding of space and time.

9. Translate the following sentences into English:

1. Досягнення фізики призвели до розвитку комп'ютерів, смартфонів і технологій медичної візуалізації.

2. Класична механіка не могла пояснити постійну швидкість світла, внаслідок чого було створено спеціальну теорію відносності.

3. Альберт Ейнштейн розробив теорію відносності, яка змінила наше уявлення про простір і час.

4. Вивчення фізики допомагає нам краще розуміти Всесвіт і модернізувати сучасні технології.

5. Вчені використовують експерименти та математичні формули для пояснення природних явищ.

10. Answer the questions to the text.

1. What does physics study?
2. Why is physics called the "fundamental science"?
3. Why is physics important in understanding the natural world?
4. Which two major theories led to the development of modern physics?
5. How did Albert Einstein contribute to physics?
6. What role does physics play in technology and daily life?
7. Why was quantum mechanics developed?
8. How do scientists study and explain natural phenomena in physics?
9. What are some real-life applications of physics in everyday life?
10. What are some fundamental forces in physics?

11. How do physicists use experiments and mathematical models to explain physical phenomena?

11. Write a short summary of the text «WHAT IS PHYSICS» (See the scheme below) and be ready to present it.

Information File - How to Write a Summary		
1. Introduction	Title	Start with the title of the article, book, or document you are summarizing.
	Author	Mention the author's name.
	Purpose	Briefly state the purpose or main idea of the original text.
2. Main Body	Key Points	Identify and present the main points or arguments of the text. Focus on the most important elements that convey the overall message.
	Supporting Details	Include relevant supporting details that help explain the key points. Avoid unnecessary specifics or minor details.
	Logical Flow	Maintain a logical flow in your summary. Present the information in the same order as it appears in the original text to ensure coherence.
3. Conclusion	Restate Main Idea	Summarize the main idea or purpose of the text in a concise manner.
	Significance	Highlight the significance or implications of the text's main points. Explain why the text is important or relevant.
	Final Thoughts	If appropriate, include any final thoughts or reflections on the text. This can be a brief statement on the overall impact of the content.

Tips for Writing a Summary

Be Concise: Keep your summary brief and to the point. Aim for clarity and brevity.

Use Your Own Words: Paraphrase the original content to avoid plagiarism and demonstrate your understanding.

Avoid Personal Opinions: Focus on summarizing the original text without inserting your own opinions or interpretations.

Check for Accuracy: Ensure that your summary accurately represents the original content. Double-check for any factual errors.

Example Summary

Title: "Exploring the Branches of Physics: From Classical Mechanics to Quantum Physics"

Author: Unknown

Purpose: The text provides an overview of various branches of physics, highlighting key concepts and their significance in scientific research and real-world applications.

Summary: Physics is a foundational science that encompasses various branches, each describing different natural phenomena. Classical mechanics, developed by Newton and Galileo, focuses on the motion of macroscopic objects and the forces acting upon them. Quantum mechanics, introduced by scientists like Planck and Einstein, explores the behavior of particles at the atomic and subatomic levels, challenging classical intuition with principles such as wave-particle duality and quantum entanglement. Other branches include electromagnetism, which studies electric and magnetic fields; thermodynamics, which examines energy transfer and temperature; and astrophysics, which investigates celestial objects. By understanding these diverse branches, students gain a comprehensive insight into the universe's underlying principles, bridging classical theories with modern discoveries.

SPEAKING

1. Guidelines for Discussion

1. Connect physics to real life.

Discuss how physics influences everyday activities, such as driving a car, using a smartphone, or cooking food. Can you think of other examples?

2. Explore famous scientists and their contributions.

Talk about Albert Einstein, Max Planck, and other physicists. How did their discoveries change our understanding of the world?

3. Debate the impact of physics on technology.

How has physics contributed to modern inventions like computers, medical imaging, and space travel? What future technologies might be possible thanks to physics?

4. Discuss challenges in learning physics.

What makes physics difficult for some students? Are there effective ways to make it easier and more interesting?

5. Speculate on the future of physics.

What are some unsolved mysteries in physics, such as dark matter or quantum mechanics? How might future discoveries change the world?

2. Render the following text into English. Summarize its main idea in one sentence.

Фізика – це фундаментальна наука, що вивчає природу, матерію, енергію та взаємодію між ними. Вона пояснює, як працює світ навколо нас – від руху планет до поведінки найменших частинок. Фізика є основою багатьох інших природничих наук, зокрема хімії, біології та астрономії, адже всі процеси у Всесвіті підпорядковуються її законам.

Сучасна фізика поділяється на два основні напрями: класичну фізику, що описує макросвіт (механіка, оптика, термодинаміка), та сучасну фізику, яка досліджує мікросвіт (квантова механіка, теорія відносності, фізика елементарних

частинок). Ці дві гілки фізики доповнюють одна одну і допомагають пояснити широкий спектр природних явищ.

Значення фізики у сучасному світі важко переоцінити. Саме завдяки досягненням цієї науки стали можливими сучасні технології: смартфони, комп'ютери, медична діагностика (МРТ, рентген), супутниковий зв'язок, лазери, електрична енергія та багато іншого. Інженери використовують закони фізики для створення міцних мостів і хмарочосів, авіаконструктори – для розробки літаків, а астрофізики – для вивчення Всесвіту.

Окрім практичного застосування, фізика має велике значення для наукового пізнання світу. Вона допомагає нам розширити межі знань про космос, будову матерії, темну енергію та гравітаційні хвилі. Фізика постійно працює над новими відкриттями, які можуть змінити наше майбутнє.

Вивчення фізики розвиває логічне мислення, аналітичні здібності та вміння розв'язувати складні задачі. Ці навички необхідні не лише в науці, а й у повсякденному житті та багатьох професіях. Тому фізика – це не просто навчальна дисципліна, а ключ до розуміння природи та технологічного прогресу людства.

EXTENDED READING

1.1⁶ Read and translate the following texts, focusing on the use of scientific terminology. Carefully select the most appropriate Ukrainian equivalents for the given terms. Create a plan for each text. Formulate the topic sentence for each text and outline its main idea.

Text 1

Influence of physics on related disciplines

Because physics elucidates the simplest fundamental questions in nature on which there can be a consensus, it is hardly surprising that it has had a profound impact on

other fields of science, on philosophy, on the worldview of the developed world, and, of course, on technology.

Indeed, whenever a branch of physics has reached such a degree of maturity that its basic elements are comprehended in general principles, it has moved from basic to applied physics and thence to technology. Thus almost all current activity in classical physics consists of applied physics, and its contents form the core of many branches of engineering. Discoveries in modern physics are converted with increasing rapidity into technical innovations and analytical tools for associated disciplines. There are, for example, such nascent fields as nuclear and biomedical engineering, quantum chemistry and quantum optics, and radio, X-ray, and gamma-ray astronomy, as well as such analytic tools as radioisotopes, spectroscopy, and lasers, which all stem directly from basic physics.

Apart from its specific applications, physics – especially Newtonian mechanics – has become the prototype of the scientific method, its experimental and analytic methods sometimes being imitated (and sometimes inappropriately so) in fields far from the related physical sciences. Some of the organizational aspects of physics, based partly on the successes of the radar and atomic-bomb projects of World War II, also have been imitated in large-scale scientific projects, as, for example, in astronomy and space research.

The great influence of physics on the branches of philosophy concerned with the conceptual basis of human perceptions and understanding of nature, such as epistemology, is evidenced by the earlier designation of physics itself as natural philosophy. Present-day philosophy of science deals largely, though not exclusively, with the foundations of physics. Determinism, the philosophical doctrine that the universe is a vast machine operating with strict causality whose future is determined in all detail by its present state, is rooted in Newtonian mechanics, which obeys that principle. Moreover, the schools of materialism, naturalism, and empiricism have in large degree considered physics to be a model for philosophical inquiry. An extreme

position is taken by the logical positivists, whose radical distrust of the reality of anything not directly observable leads them to demand that all significant statements must be formulated in the language of physics.

The uncertainty principle of quantum theory has prompted a reexamination of the question of determinism, and its other philosophical implications remain in doubt. Particularly problematic is the matter of the meaning of measurement, for which recent theories and experiments confirm some apparently noncausal predictions of standard quantum theory. It is fair to say that though physicists agree that quantum theory works, they still differ as to what it means.

Text 2

Influence of related disciplines on physics

The relationship of physics to its bordering disciplines is a reciprocal one. Just as technology feeds on fundamental science for new practical innovations, so physics appropriates the techniques and instrumentation of modern technology for advancing itself. Thus experimental physicists utilize increasingly refined and precise electronic devices. Moreover, they work closely with engineers in designing basic scientific equipment, such as high-energy particle accelerators. Mathematics has always been the primary tool of the theoretical physicist, and even abstruse fields of mathematics such as group theory and differential geometry have become invaluable to the theoretician classifying subatomic particles or investigating the symmetry characteristics of atoms and molecules. Much of contemporary research in physics depends on the high-speed computer. It allows the theoretician to perform computations that are too lengthy or complicated to be done with paper and pencil. Also, it allows experimentalists to incorporate the computer into their apparatus, so that the results of measurements can be provided nearly instantaneously on-line as summarized data while an experiment is in progress.

1.2* Comprehension Questions:

- How does physics influence technological advancements and applied sciences?
- In what ways has the scientific method in physics been adopted by other disciplines?
- What are some examples of analytical tools and innovations that have emerged directly from physics?
- Why do physicists still debate the meaning of quantum theory, even though they agree that it works?

1.3* Vocabulary and Terminology:

- Define the following terms: engineering, gamma-ray astronomy, universe, space research, standard quantum theory, implication.
- Translate the key terms into your native language and use them in sentences.

1.4* Write a brief summary of influence of physics on related disciplines mentioned in the text.

1.5* Discussion Prompts:

1. Physics and Other Disciplines: In what ways has physics contributed to advancements in other scientific fields? Can you think of any recent technological innovations that originated from physics?

2. Scientific Method and Its Influence: Do you think applying the scientific method of physics to other disciplines (like social sciences) is always appropriate? Why or why not?

3. Determinism vs. Quantum Mechanics: How does the uncertainty principle challenge the traditional deterministic view of the universe? Do you believe the universe operates under strict laws, or is there room for randomness?

4. Ethical Implications of Physics in Technology: Physics has led to both beneficial technologies (e.g., medical imaging) and destructive ones (e.g., nuclear weapons). How should society balance scientific progress with ethical responsibility?

5. Philosophy and Science: Given that physics has deeply influenced philosophy, do you think scientific discoveries should shape our understanding of reality, or should philosophy remain independent of science?

1.6* Research and Presentation:

Prepare a presentation *"The Impact of Physics on Modern Technology and Society"*.

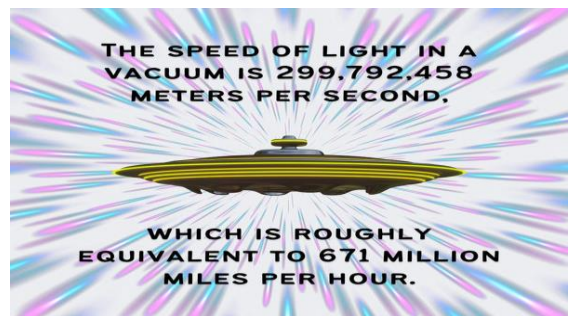
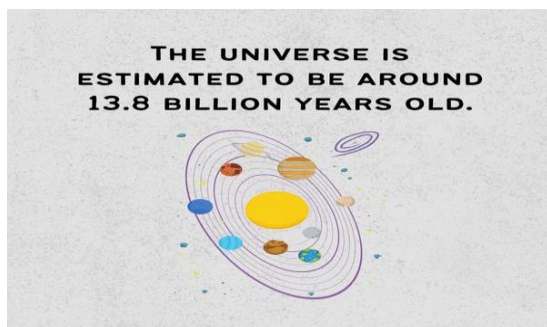
- Explore how fundamental discoveries in physics have led to technological advancements.
- Analyze real-world applications of physics in fields like medicine, engineering, and space exploration.
- Discuss ethical and societal implications of physics-driven innovations (e.g., nuclear energy, artificial intelligence, quantum computing).

1.7* Read and translate the following information about some physics fun facts.

Some Physics Fun Facts Only Physicists Know

→ Bananas contain potassium, and since potassium decays, that makes them slightly radioactive. Consuming many millions of bananas in a short period of time would reach a lethal dose.

→ All of humanity could fit in a sugar cube. Because atoms are 99% empty space. A hydrogen atom, for example, is about 99.9999999999996% empty space.



→ The sun doesn't require oxygen to burn. Its energy is generated through nuclear fusion. A process that occurs due to the extreme heat and pressure in its core.

→ A teaspoonful of neutron star would weigh billions of tons on Earth.

→ You can yell at your soup to warm it up. However, sound waves carry minimal energy, so the effect would be unnoticeable.

→ The Earth's magnetic field, which protects us from solar storms and cosmic radiation, is generated by the movement of molten iron in its outer core.

→ Time goes faster at the top of the building than at the bottom. The further away you are from the force of gravity, the faster time will pass for you, and vice versa.

→ Newton once put a needle in his eye to check the influence on his vision. He stuck a blunt needle into his eye socket and recorded seeing colored circles and other visual phenomena.

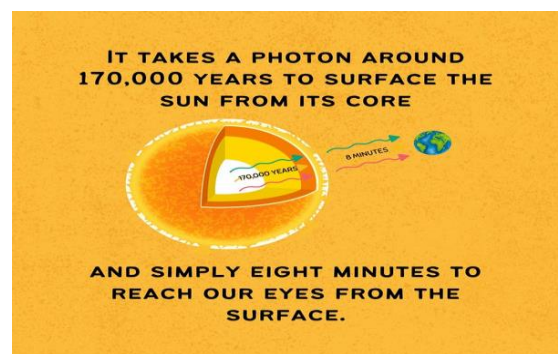
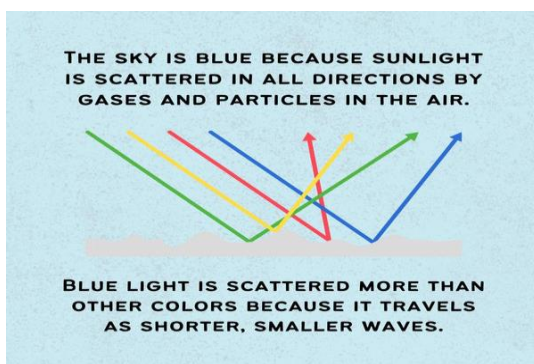
→ The sun's color changes while setting or rising due to a phenomenon called scattering. This means that shorter wavelengths of light scatter away, and only longer wavelengths of light reach our eyes. Resulting in a yellow-orange sunset.

→ The smell of space has been described as seared steak, hot metal, and welding fumes. The reason is polycyclic aromatic hydrocarbons (PAHs). These molecules are by-products of dying stars.

→ When helium is cooled to absolute zero, it turns into what's known as a superfluid. It streams against gravity, crawling up and over the sides of compartments.

→ Mars' two moons are named Phobos and Deimos, actually meaning fear and panic.

→ Light travels the fastest, which is not entirely true. Light slows down slightly when it passes through an absorbing medium like water or glass.



→ If you hold up a grain of sand at arm's length, the patch of sky it covers contains 10,000 galaxies! Each galaxy contains 10 million to a thousand billion stars.

Conclusion:

These physics fun facts are just a taste of the incredible world where everything from tiny atoms to the vast universe is governed by the laws of physics. It's not just about complex equations (though those can be fascinating too); physics is about understanding the very fabric of reality.

The next time you see a bright sunset (light waves!), feel the pull of gravity (yes, it's real!), or simply throw a frisbee (motion and forces!), remember the power of physics.

After all, science is everywhere, and it can be a whole lot of fun!

1.8* Rephrase in English. Make a project about essential facts about Physics.

UNIT 2

KEY BRANCHES OF PHYSICS

Part 1

TEXT

Exploring the Branches of Physics

1. a) Read and translate the text using the dictionary:

Physics, the foundational science, encompasses a vast array of branches that describe the natural phenomena governing our universe. Beginning with classical mechanics, which delves into the motion of macroscopic objects and the forces acting upon them, the field extends to the sophisticated realm of quantum mechanics, where the behavior of particles at the atomic and subatomic levels defies classical intuition.

Classical mechanics, developed by pioneers like Newton and Galileo, laid the groundwork for understanding motion and energy. This branch covers topics such as kinematics, dynamics, and thermodynamics, providing critical insights into everyday phenomena and engineering applications. As our understanding deepened, physicists ventured into electromagnetism, exploring electric and magnetic fields and their interactions.

As we delve into the fascinating world of physics, it's essential to explore the different branches that make up this vast field of study. Each branch offers unique insights and principles that help us understand the complexities of the universe. From the foundational concepts of classical mechanics to the enigmatic nature of quantum mechanics, each discipline plays a crucial role in advancing our knowledge and technology. Let's embark on this journey by examining the key branches of physics and their significance:

Classical Mechanics is the branch of physics that deals with the motion of macroscopic objects. It encompasses concepts such as kinematics, dynamics, and energy conservation. Developed by Newton and Galileo, it forms the foundation for many engineering applications and helps explain everyday phenomena, from the motion of planets to the mechanics of machines.

Electromagnetism explores the behavior of electric and magnetic fields and their interactions. Pioneered by Maxwell, this branch of physics covers a wide range of topics, including electric circuits, electromagnetic waves, and magnetic fields. Applications of electromagnetism are found in technologies such as generators, motors, and communication systems.

Thermodynamics is the study of heat, energy, and work. It involves understanding the laws of thermodynamics, which describe how energy is transferred and transformed. Key concepts include temperature, entropy, and heat engines. Thermodynamics is crucial in fields such as engineering, chemistry, and environmental science.

Quantum Mechanics is the branch of physics that deals with the behavior of particles at the atomic and subatomic levels. It introduces principles like wave-particle duality, quantum entanglement, and the uncertainty principle. Quantum mechanics challenges classical intuition and has led to the development of technologies such as semiconductors and quantum computers.

Relativity, developed by Einstein, consists of two theories: special relativity and general relativity. Special relativity addresses the behavior of objects moving at high speeds and introduces concepts such as time dilation and length contraction. General relativity extends these ideas to include gravity, describing it as the curvature of spacetime. Relativity has profound implications for our understanding of the universe.

Astrophysics is the study of celestial objects and phenomena beyond Earth's atmosphere. It encompasses the physics of stars, galaxies, black holes, and the overall

structure of the universe. Astrophysics seeks to answer fundamental questions about the origin, evolution, and fate of the cosmos, using tools such as telescopes and satellites.

Particle Physics explores the fundamental particles that make up matter and the forces that govern their interactions. This branch of physics investigates the smallest building blocks of the universe, such as quarks, leptons, and bosons. Research in particle physics is conducted using high-energy particle accelerators and has led to discoveries like the Higgs boson.

Nuclear Physics focuses on the properties and behavior of atomic nuclei. It involves the study of nuclear reactions, radioactive decay, and the forces that hold nuclei together. Applications of nuclear physics include nuclear energy, medical imaging, and radiation therapy. Understanding nuclear processes is essential for both power generation and scientific research.

Statistical Mechanics combines principles of probability and physics to explain the behavior of large ensembles of particles. It bridges the gap between microscopic and macroscopic phenomena by describing how individual particle interactions lead to observable properties such as temperature and pressure. Statistical mechanics is fundamental in understanding phase transitions and critical phenomena.

Biophysics applies the principles of physics to study biological systems. It focuses on understanding the physical mechanisms underlying biological processes at the molecular and cellular levels. Topics in biophysics include the structure and function of proteins, DNA, and membranes. Biophysics plays a crucial role in advancing fields such as molecular biology, medicine, and biotechnology.

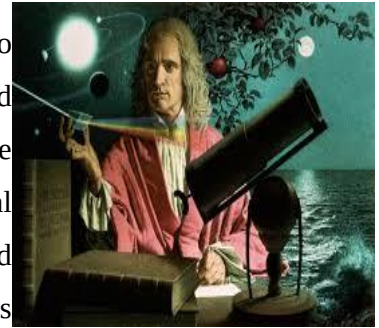
b) Translate the italicized paragraphs into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

Notes:

1. Sir **Isaac Newton** (1643-1727) was a pioneering English scientist who made significant contributions to physics and mathematics. He formulated the three laws of motion and the law of universal gravitation, which laid the foundation for classical mechanics and explained the motion of celestial bodies. Newton also developed calculus independently of Leibniz, conducted groundbreaking research in optics, and invented the reflecting telescope. His work, particularly in his book "Philosophiæ Naturalis Principia Mathematica," has had a profound and lasting impact on modern science.



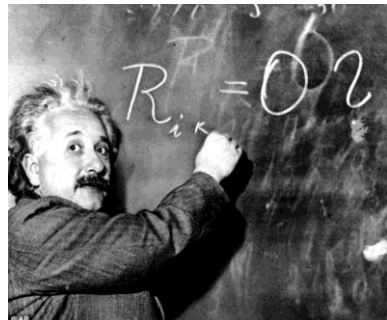
2. **Galileo Galilei** (1564-1642) was an Italian astronomer, physicist, and mathematician who played a crucial role in the scientific revolution. He is best known for his pioneering use of the telescope to observe celestial bodies, leading to significant discoveries such as the moons of Jupiter, the phases of Venus, and the detailed observations of the Moon's surface. Galileo's support for the heliocentric model of the solar system, proposed by Copernicus, challenged the geocentric view and led to conflicts with the Catholic Church. His work in kinematics and dynamics laid the groundwork for classical mechanics, and his contributions to the scientific method emphasized experimentation and observation. Galileo's legacy as the "father of modern observational astronomy" and "father of modern physics" continues to influence science to this day.

3. **James Clerk Maxwell** (1831-1879) was a Scottish physicist best known for his formulation of the classical theory of electromagnetic radiation. He unified the existing knowledge of electricity and magnetism into a single theoretical framework, encapsulated in Maxwell's equations. These equations describe how electric and magnetic fields are generated and altered by each other and by charges and currents. Maxwell's work laid the foundation for modern physics and paved the way for significant advancements in understanding light, radio waves, and electromagnetic fields. His contributions also extended to the kinetic theory of gases, where he developed the Maxwell-Boltzmann distribution, describing the statistical distribution of particle speeds in a gas. Maxwell's innovative approach and profound insights have had a lasting impact on both theoretical and experimental physics.



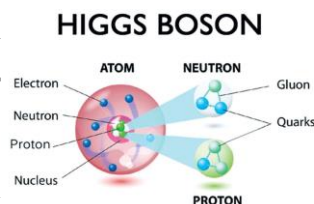
James Clerk Maxwell
(1831-1879)

4. Albert Einstein (1879-1955) was a German-born theoretical physicist whose groundbreaking work



revolutionized our understanding of the physical world. He is best known for developing the theory of relativity, which includes the famous equation $E=mc^2$. Einstein's general theory of relativity, which describes gravity as the curvature of spacetime, has had a profound impact on modern physics and our understanding of the universe. In addition to his work on relativity, Einstein made significant contributions to the development of quantum mechanics, particularly through his explanation of the photoelectric effect, for which he was awarded the Nobel Prize in Physics in 1921. Einstein's innovative ideas and deep insights have made him one of the most influential scientists in history.

5. The Higgs boson, often referred to as the "God particle," is a fundamental particle discovered in 2012 at the Large Hadron Collider (LHC) at CERN. It plays a crucial role in the Standard Model of particle physics by explaining the origin of mass. The Higgs boson is associated with the Higgs field, an invisible field that permeates the universe. When particles interact with this field, they acquire mass. The discovery of the Higgs boson confirmed the existence of the Higgs field and validated the mechanism proposed by physicist Peter Higgs and others in the 1960s. This discovery has profound implications for our understanding of the fundamental structure of matter and the forces that govern the universe.



2. Synonym Groups for Physics Vocabulary:

Select five key terms from the text. For each term, create a list of 2 to 6 synonyms that capture the same or similar meanings within the context of physics. Below are examples to guide you:

1. **Physics** - Physical science - Natural philosophy
2. **Phenomena** — Events — Occurrences - Manifestations
3. **Universe** — Cosmos — Space - World
4. **Classical Mechanics** - Traditional mechanics - Newtonian mechanics
5. **Quantum Mechanics** - Quantum physics - Quantum theory
6. **Motion** — Movement — Locomotion - Kinetics

7. **Energy** — Power — Vitality - Force
8. **Fields** — Domains — Areas - Regions
9. **Interactions** — Reactions — Connections – Exchanges
10. **Particles** — Atoms — Molecules - Subatomic particles

3. Using the dictionary transcribe and translate the key words:

Word	Transcription	Translation
Foundation		
Principles		
Macroscopic		
Atomic		
Subatomic		
Kinematics		
Dynamics		
Entropy		
Conservation		
Wave-particle duality		
Quantum entanglement		
Uncertainty principle		
Time dilation		
Space-time curvature		
High-energy		

4. Match the words with their definition:

1. Foundational	a) The branch of mechanics concerned with the forces and torques and their effect on motion.
2. Macroscopic	b) Relating to objects that are large enough to be seen with the naked eye.

3. Subatomic	c) The bending of space and time around massive objects, as described by Einstein's theory of general relativity.
4. Kinematics	d) A measure of the disorder or randomness in a system.
5. Dynamics	e) The branch of mechanics that describes the motion of objects without considering the forces causing the motion.
6. Entropy	f) A principle stating that it is impossible to simultaneously know the exact position and momentum of a particle.
7. Wave-particle duality	g) The concept that particles can exhibit both wave-like and particle-like properties.
8. Quantum entanglement	h) Serving as the basis or groundwork for something.
9. Uncertainty principle	i) A phenomenon where particles become interconnected such that the state of one particle instantly influences the state of another, regardless of the distance between them.
10. Space-time curvature	j) Pertaining to particles smaller than an atom.

5. Give English equivalents to the meanings of the following words and word combinations:

фундаментальна наука	
природні явища	
поведінка частинок	
рух та енергія	
інженерні програми	
збереження енергії	
електричні схеми	

тепло	
енергія передається і перетворюється	
екологія	
на атомному та субатомному рівнях	
корпускулярно-хвильовий дуалізм	
принцип невизначеності	
напівпровідник	
предмети, що рухаються на великій швидкості	
затягування часу	
скорочення довжини	
небесні об'єкти	
супутник	
матерія	
атомні ядра	
радіоактивний розпад	
принципи ймовірності	
на молекулярному та клітинному рівнях	
ДНК	

6. Find synonyms to the words and word combinations:

1. Encompass -
2. Macroscopic -
3. Extend -
4. Sophisticated -

- 5. Behavior -
- 6. Intuition -
- 7. Insights -
- 8. Principles -
- 9. Interactions –
- 10. Pioneers -
- 11. Advent -
- 12. Groundbreaking -

7. Choose the correct answer:

1. Which branch of physics deals with the motion of macroscopic objects and the forces acting upon them?
 - A) Quantum Mechanics
 - B) Electromagnetism
 - C) Classical Mechanics
 - D) Astrophysics
2. What principle is introduced in quantum mechanics that challenges classical intuition?
 - A) Thermodynamics
 - B) Quantum Entanglement
 - C) Time Dilation
 - D) Space-time Curvature
3. Which scientist is known for developing the theories of special and general relativity?
 - A) Newton
 - B) Galileo
 - C) Planck
 - D) Einstein

4. What is the primary focus of astrophysics?
 - A) Study of electric and magnetic fields
 - B) Study of celestial objects and phenomena
 - C) Study of heat, energy, and work
 - D) Study of atomic nuclei
5. Which branch of physics investigates the smallest building blocks of the universe?
 - A) Thermodynamics
 - B) Particle Physics
 - C) Nuclear Physics
 - D) Electromagnetism
6. What concept does classical mechanics primarily cover?
 - A) Kinematics and dynamics
 - B) Quantum superposition
 - C) Space-time curvature
 - D) Nuclear decay
7. Which phenomenon is described by the uncertainty principle?
 - A) The behavior of large celestial bodies
 - B) The exact position and momentum of a particle
 - C) The conservation of energy
 - D) The interactions between electric and magnetic fields
8. What is one of the main applications of electromagnetism?
 - A) Study of atomic nuclei
 - B) Understanding the structure of DNA
 - C) Technologies like generators and communication systems
 - D) Analysis of chemical reactions

9. Which is the best way to translate the following sentence:

Classical mechanics, developed by pioneers like Newton and Galileo, laid the groundwork for understanding motion and energy.

A) Класична механіка, розроблена піонерами, як-от Ньютон і Галілей, заклала основи для розуміння руху та енергії.

B) Класична механіка, створена піонерами, такими як Ньютон і Галілей, заклала підґрунтя для розуміння руху та енергії.

C) Класична механіка, заснована піонерами, як Ньютон і Галілей, заклала фундамент для вивчення руху та енергії.

D) Класична механіка, розроблена піонерами, такими як Ньютон і Галілей, заклала основу для дослідження руху та енергії.

10. Which is the best way to translate the following sentence:

The 20th century heralded a revolutionary shift with the advent of quantum mechanics, introduced by scientists like Planck, Einstein, and Schrödinger.

A) 20-е століття ознаменувало революційний зсув з появою квантової механіки, запровадженої вченими, такими як Планк, Ейнштейн і Шредінгер.

B) 20 століття принесло революційний злам із запровадженням квантової механіки, яку створили вчені, такі як Планк, Ейнштейн і Шредінгер.

C) 20 століття ознаменувало революційний поворот із появою квантової механіки, запропонованої вченими, такими як Планк, Ейнштейн і Шредінгер.

D) 20-е століття призвело до революційного розвитку з виникненням квантової механіки, запровадженої вченими, такими як Планк, Ейнштейн і Шредінгер.

8. Translate the following sentences into Ukrainian:

1. Quantum mechanics defies classical intuition by introducing principles such as wave-particle duality and quantum entanglement.

2. Thermodynamics involves the study of energy transfer, temperature, and the laws governing these processes.

3. Classical mechanics, developed by pioneers like Newton, provides critical insights into everyday phenomena and engineering applications.

4. Astrophysics explores the behavior and properties of celestial objects, including stars, galaxies, and black holes.

5. The uncertainty principle states that it is impossible to simultaneously determine the exact position and momentum of a particle.

9. Translate the following sentences into English:

1. Електромагнетизм є основою багатьох сучасних технологій, включаючи генератори та системи зв'язку.

2. Розвиток астрофізики дозволив вченим краще зрозуміти структуру та еволюцію Всесвіту.

3. Статистична механіка використовує ймовірнісні методи для опису поведінки великих ансамблів частинок.

4. Класична механіка грає ключову роль в інженерних розрахунках і проектуванні машин.

5. Дослідження частинок дозволяє вченим зрозуміти фундаментальні взаємодії в природі.

10. Answer the questions to the text.

1. What is the primary focus of classical mechanics?

2. Which scientists are credited with the development of classical mechanics?

3. How does quantum mechanics differ from classical mechanics?

4. What are some key principles introduced by quantum mechanics?

5. Who were the prominent scientists that contributed to the advent of quantum mechanics?

6. What does electromagnetism study, and what are its applications?

7. How did the 20th century revolutionize physics with the introduction of quantum mechanics?

8. What are the main areas of focus within astrophysics?

9. What does the uncertainty principle state about particles?
10. How does relativity challenge our understanding of space and time?

11. Write a short summary of the text (See the scheme in the Information File (Ex. 11, P. 16) and be ready to present it.

EXTENDED READING *

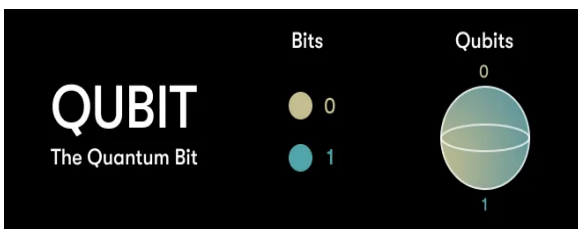
1.1* Read and translate the following text. Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Text

New Discoveries and Innovations

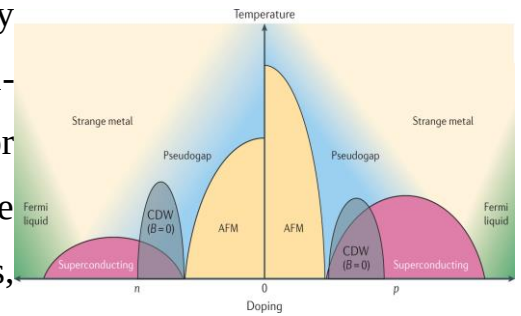
Physics continues to evolve with groundbreaking research and discoveries that push the boundaries of our understanding. Here, we delve into some recent advancements across various branches of physics, showcasing how these developments are shaping the future of science and technology.

Quantum Computing Advancements: Recent research in quantum computing has

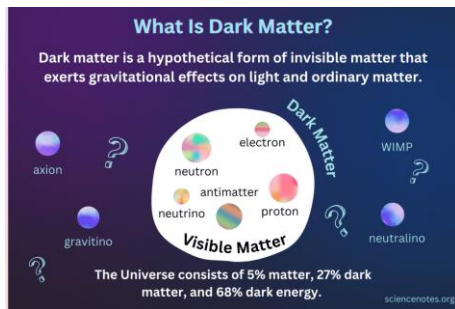


led to significant strides in creating more stable qubits, the fundamental units of quantum information. Scientists at major research institutions have developed new error-correction techniques, bringing us closer to the realization of practical quantum computers. These advancements promise to revolutionize fields such as cryptography, materials science, and complex system simulations.

Revolutionizing Materials with Superconductors: Superconductivity has always fascinated physicists due to its potential to dramatically enhance electrical efficiency. Recent discoveries of high-temperature superconductors have opened new avenues for research. Researchers are now exploring the use of these materials in developing ultra-efficient power grids, advanced magnetic resonance imaging (MRI) machines, and powerful particle accelerators, paving the way for unprecedented technological advancements.



Unveiling the Mysteries of Dark Matter: One of the most intriguing questions in



cosmology is the nature of dark matter. Recent observational data from telescopes and space missions have provided new insights into the distribution and behavior of dark matter in the universe. Scientists are employing cutting-edge techniques, such as weak

gravitational lensing and high-energy particle detectors, to shed light on this elusive component of the cosmos.

Breakthroughs in Astrophysics: The study of black holes has seen remarkable progress with the first-ever image of a black hole captured by the Event Horizon Telescope (EHT). This groundbreaking achievement has confirmed several predictions of Einstein's general theory of relativity and opened new research paths in understanding the behavior of matter and energy in extreme gravitational fields. Additionally, the discovery of gravitational waves continues to provide valuable information about cosmic events, such as neutron star mergers.



Nanotechnology and Condensed Matter Physics: The field of condensed matter physics has seen significant advancements in nanotechnology, particularly in the development of two-dimensional materials like graphene.

These materials exhibit extraordinary electrical, thermal, and mechanical properties, making them ideal for applications in flexible electronics, advanced sensors, and energy storage devices. Ongoing research aims to harness these properties for commercial and industrial use, driving innovation in various sectors.

Innovations in Thermodynamics and Energy Systems: Thermodynamics remains a vital area of research, with scientists exploring new ways to improve energy conversion and efficiency. Recent studies have focused on the development of thermoelectric materials, which can directly convert heat into electricity. These materials hold the potential to revolutionize waste heat recovery systems, enabling more sustainable and efficient energy usage in industries and transportation.

1.2* Comprehension Questions:

1. What recent advancements have been made in quantum computing, and what potential applications do they have?
2. Explain the significance of the first-ever image of a black hole and its impact on our understanding of general relativity.
3. What are some potential applications of high-temperature superconductors mentioned in the text?

1.3* Vocabulary and Terminology:

- Define the following terms: qubit, dark matter, Event Horizon Telescope, gravitational waves, nanotechnology.
- Translate the key terms into your native language and use them in sentences.

1.4* Write a brief summary of the advancements in one of the fields mentioned in the text (e.g., quantum computing, superconductivity, astrophysics).

1.5* Discussion Prompts:

- Discuss the implications of dark matter research for our understanding of the universe.
What challenges do scientists face in studying dark matter?
- Reflect on how nanotechnology and condensed matter physics are transforming the development of new materials and their applications in various industries.

1.6* Research and Presentation:

Choose one of the recent advancements in physics mentioned in the text and conduct further research on it. Prepare a presentation to share your findings with the class.

UNIT 3

KEY BRANCHES OF PHYSICS

Part 2

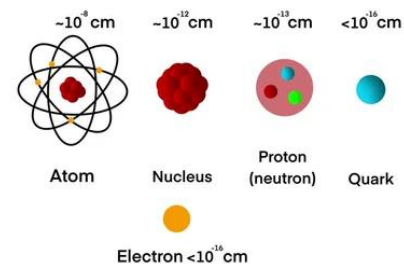
TEXT

Advanced Concepts and Modern Applications

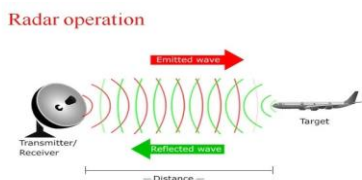
1. a) Read and translate the text using the dictionary:

As we explore the fundamental branches of physics, it's essential to delve deeper into advanced concepts and their modern applications. The interplay between classical theories and contemporary discoveries has paved the way for groundbreaking advancements in science and technology.

Advanced Quantum Mechanics: Building on the foundational principles of quantum mechanics, advanced topics include quantum field theory and quantum computing. Quantum field theory extends the concepts of particle physics by describing particles as excitations in underlying fields. Quantum computing leverages the principles of superposition and entanglement to perform computations far beyond the capabilities of classical computers.

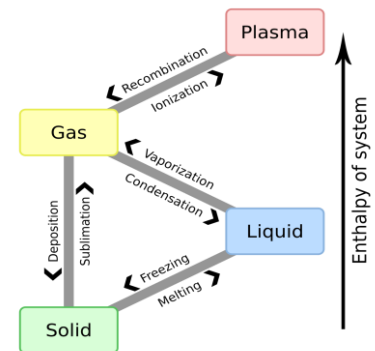


Electrodynamics extends electromagnetism by studying the behavior of electric and magnetic fields in dynamic situations. It encompasses the interactions of charges and currents, the propagation of electromagnetic waves, and the principles of waveguides and antennas. Electrodynamics is crucial for understanding and developing advanced communication systems, radar

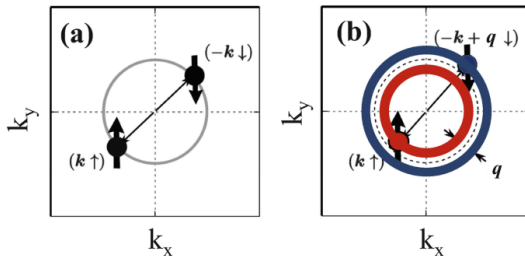


technology, and microwave engineering.

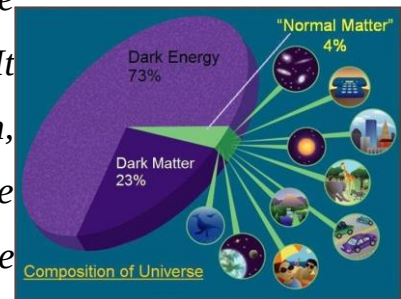
Statistical Mechanics bridges the microscopic and macroscopic worlds by using statistical methods to describe the behavior of large ensembles of particles. This branch of physics provides insights into the thermodynamic properties of systems, such as entropy, temperature, and pressure. It is essential for understanding phase transitions, critical phenomena, and the behavior of gases, liquids, and solids.



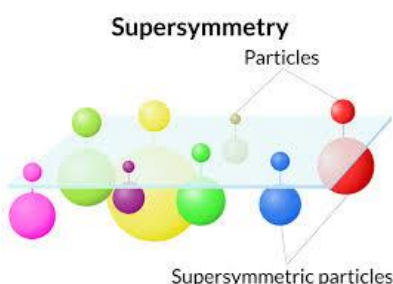
Condensed Matter Physics focuses on the properties of solid and liquid states of matter. It explores phenomena such as superconductivity, magnetism, and crystallography. This field has led to the development of advanced materials with unique properties, such as graphene, and has significant implications for electronics, nanotechnology, and quantum materials.



Cosmology, a subfield of astrophysics, investigates the large-scale structure and evolution of the universe. It addresses fundamental questions about the origin, composition, and fate of the universe. Key concepts include the Big Bang theory, dark matter, dark energy, and the cosmic microwave background radiation. Modern cosmology combines observational data with theoretical models to unravel the mysteries of the cosmos.



High-Energy Physics, also known as particle physics, studies the fundamental particles and forces that make up the universe. Experiments conducted in particle accelerators, such as the Large Hadron Collider, aim to discover new particles and understand their



interactions. *This field has led to the discovery of the Higgs boson and continues to explore phenomena such as supersymmetry and extra dimensions.*

Interdisciplinary Research: Physics continues to intersect with other scientific disciplines, leading to interdisciplinary research areas such as biophysics, geophysics, and materials science. Biophysics applies physical principles to understand biological systems, geophysics explores the physical properties of the Earth, and materials science investigates the structure and properties of materials for various applications.

In conclusion, the study of advanced concepts in physics and their modern applications highlights the dynamic and ever-evolving nature of this field. By integrating classical theories with contemporary discoveries, physicists continue to push the boundaries of our understanding, leading to innovative technologies and profound insights into the fundamental workings of the universe.

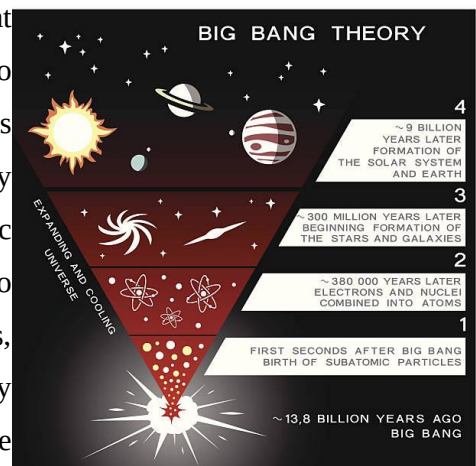
b) Translate the italicized paragraphs into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

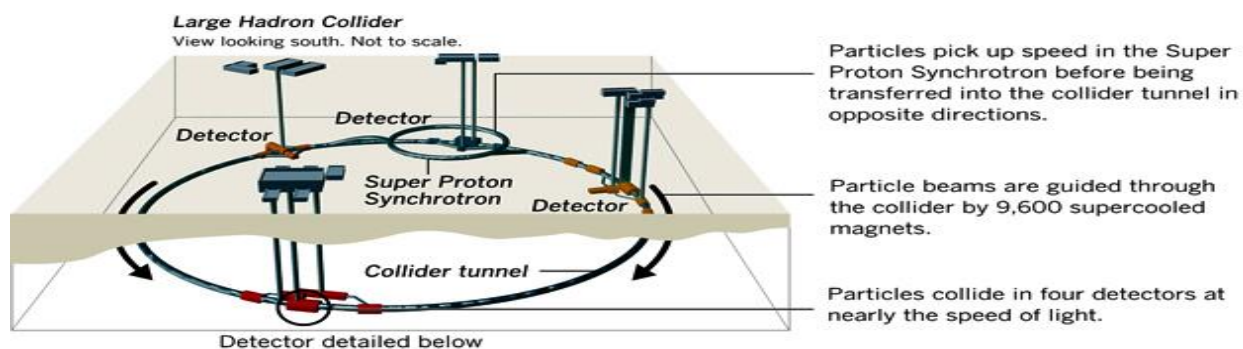
Notes

1. The Big Bang theory is the prevailing cosmological model that describes the origin and evolution of the universe. According to this theory, the universe began approximately 13.8 billion years ago from an extremely hot and dense singularity. It then rapidly expanded and cooled, leading to the formation of subatomic particles and eventually atoms. As the universe continued to expand, gravitational forces caused matter to coalesce into stars, galaxies, and larger cosmic structures. The theory is supported by several key observations, including the cosmic microwave background radiation, the abundance of light elements, and the redshift of distant galaxies, which indicate



that the universe is still expanding.

2. The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator, located at CERN (the European Organization for Nuclear Research) near Geneva, Switzerland. It consists of a 27-kilometer ring of superconducting magnets and is designed to collide protons and heavy ions at unprecedented energies. The LHC aims to explore fundamental questions about the universe by recreating conditions similar to those just moments after the Big Bang. Key discoveries include the Higgs boson, which confirmed the existence of the Higgs field, providing insights into the origin of mass. The LHC continues to push the boundaries of particle physics, uncovering new particles and enhancing our understanding of fundamental forces.



2. Synonym Groups for Physics Vocabulary:

Select 5 key terms from the text. For each term create a list of 2 to 6 synonyms that capture the same or similar meanings within the context of physics. Below are examples to learn and to guide you.

1. **Cosmology** - Astrophysical Cosmology - Physical Cosmology - Cosmological Studies
2. **Entropy** — Disorder - Entropic Measure - Thermodynamic Entropy
3. **Dark Matter** - Invisible Matter - Non-Luminous Matter - Hidden Mass
4. **Entanglement** — Intertwinement — Interconnection
5. **Waveguide** — Conduit - Transmission Line
6. **Phonon** - Quantum of Sound - Lattice Vibration

7. **Quasiparticle** - Collective Excitation - Effective Particle
8. **Superconductor** - Perfect Conductor - Zero-Resistance Material
9. **Diffraction** - Bending of Waves — Scattering
10. **Coherence** — Consistency - Phase Relationship
11. **Oscillation** — Vibration — Fluctuation
12. **Spectroscopy** - Spectrum Analysis - Light Analysis

3. Using the dictionary transcribe and translate the key words:

Word	Transcription	Translation
Superposition		
Entanglement		
Waveguide		
Phonon		
Quasiparticle		
Superconductor		
Diffraction		
Coherence		
Oscillation		
Spectroscopy		
Advanced		
Advanced		
Fundamental		
Propagate		
Excite		

4. Match the words with their definition:

1. Quantum Computing	a) The residual thermal radiation from the Big Bang, filling the universe almost uniformly and providing evidence for its origin.
2. Electromagnetic Waves	b) Waves of electric and magnetic fields that propagate through space and carry energy. Examples include light, radio waves, and microwaves.
3. Kinetic Theory:	c) A change in the physical state or phase of a substance, such as from solid to liquid or liquid to gas, often accompanied by changes in properties like density and energy.
4. Crystallography	d) A theory that describes the behavior of gases in terms of the motion of their individual molecules, explaining properties such as pressure and temperature.
5. Gravitational Waves	e) A measure of the disorder or randomness in a system, often associated with the second law of thermodynamics, indicating the direction of spontaneous processes.
6. Phase Transition	f) A theoretical framework in particle physics that proposes a symmetry between fermions and bosons, potentially explaining various fundamental forces and particles.
7. Cosmic Microwave Background	g) Ripples in the fabric of spacetime caused by the acceleration of massive objects, predicted by Einstein's general theory of relativity.
8. Supersymmetry:	h) The science and engineering of manipulating materials

	at the atomic or molecular scale, often involving structures with dimensions less than 100 nanometers.
9. Nanotechnology	i) A type of computation that harnesses the principles of quantum mechanics, such as superposition and entanglement, to perform operations on data.
10. Entropy	j) The study of the structure, properties, and formation of crystals, often using techniques such as X-ray diffraction.

5. Give English equivalents to the meanings of the following words and word combinations:

передові концепції	
сучасні відкриття	
новаторські досягнення в науці	
використовувати важелі	
принципи суперпозиції	
виконувати обчислення	
взаємодія зарядів і струмів	
хвилеводи і антени	
передові системи зв'язку	
ентропія	
фазові переходи	
поведінка газів, рідин і твердих тіл	
фізика конденсованого стану	

твердий і рідкий стани речовини	
надпровідність	
масштабна структура	
походження, склад і доля Всесвіту	
теорія великого вибуху	
Фізика високих енергій	
Великий андронний колайдер	
перетинатися з	
міждисциплінарні напрямки досліджень	
інноваційні технології	

6. Find synonyms to the words and word combinations:

1. Advanced -
2. Describe -
3. Dynamic -
4. Expand -
5. Investigate
6. Discover -
7. Fundamental -
8. Significant -
9. Interactions -
10. Structure -

7. Choose the correct answer:

1. What principle allows quantum computers to perform operations beyond the capabilities of classical computers?

- A) Superposition and Entanglement
- B) Classical Mechanics
- C) Waveguides
- D) Thermal Conduction

2. Which branch of physics extends electromagnetism by studying electric and magnetic fields in dynamic situations?

- A) Quantum Mechanics
- B) Electrodynamics
- C) Statistical Mechanics
- D) Cosmology

3. What does the kinetic theory describe?

- A) The propagation of electromagnetic waves
- B) The behavior of gases in terms of the motion of their individual molecules
- C) The structure of crystals
- D) The interaction of electric and magnetic fields

4. What is studied in crystallography?

- A) The structure, properties, and formation of crystals
- B) The behavior of subatomic particles
- C) The principles of superposition and entanglement
- D) The expansion of the universe

5. Which theory predicts gravitational waves?

- A) Quantum Field Theory
- B) General Theory of Relativity
- C) Kinetic Theory
- D) Maxwell's Equations

6. What is a phase transition?

- A) A change in the physical state or phase of a substance
- B) The behavior of electric and magnetic fields
- C) The statistical distribution of particle speeds in a gas
- D) The residual thermal radiation from the Big Bang

7. What is the cosmic microwave background?

- A) A quantum field
- B) Ripples in spacetime caused by massive objects
- C) Residual thermal radiation from the Big Bang
- D) An advanced communication system

8. What does supersymmetry propose?

- A) A symmetry between fermions and bosons
- B) The behavior of gases
- C) The bending of waves
- D) The statistical methods to describe large ensembles of particles

9. Which is the best way to translate the following sentence:

Quantum computing leverages the principles of superposition and entanglement to perform computations far beyond the capabilities of classical computers.

A) Квантові обчислення використовують принципи суперпозиції та запутаності для виконання обчислень, які значно перевищують можливості класичних комп'ютерів.

B) Квантове програмування використовує принципи надпозиції та зчеплення для виконання обчислень, які значно перевищують можливості класичних комп'ютерів.

C) Квантові обчислення застосовують принципи суперпозиції та запутаності для проведення розрахунків, які значно поступаються можливостям класичних комп'ютерів.

D) Квантове обчислення використовує принципи суперпозиції та зчеплення для проведення розрахунків, які значно перевищують можливості класичних комп'ютерів.

10. Which is the best way to translate the following sentence:

Crystallography, the study of the structure, properties, and formation of crystals, has led to the development of advanced materials with unique properties.

A) Кристалографія, дослідження структури, властивостей і утворення кристалів, привела до розвитку передових матеріалів з унікальними властивостями.

B) Кристалографія, вивчення структури, властивостей і утворення кристалів, призвела до створення передових матеріалів з унікальними властивостями.

C) Кристалографія, дослідження структури, характеристик і утворення кристалів, призвела до розробки передових матеріалів з унікальними характеристиками.

D) Кристалографія, дослідження структури, властивостей і утворення кристалів, привела до розробки передових матеріалів з унікальними властивостями.

8. Translate the following sentences into Ukrainian:

1. Quantum field theory offers a framework that describes particles as excitations in underlying fields, enabling a deeper understanding of particle interactions.

2. Electrodynamics encompasses the study of electromagnetic waves and their propagation through various media, playing a crucial role in modern communication technologies.

3. In statistical mechanics, the distribution of particle speeds in a gas can be described using the Maxwell-Boltzmann distribution, a fundamental concept in thermodynamics.

4. The discovery of superconductivity has revolutionized the field of condensed matter physics, leading to the development of materials with zero electrical resistance.

5. Cosmology investigates the large-scale structure of the universe, examining phenomena such as dark matter, dark energy, and the cosmic microwave background radiation.

9. Translate the following sentences into English:

1. Квантова механіка відкрила нові горизонти для розуміння мікросвіту, описуючи поведінку частинок на атомному та субатомному рівнях.

2. Хвилеводи використовуються для направлення електромагнітних хвиль у телекомунікаційних системах з мінімальними втратами енергії.

3. Фоони є квантуванням коливань атомів у кристалічній решітці, що допомагає описати теплопровідність матеріалів.

4. Суперпровідники мають унікальну властивість, що дозволяє їм проводити електричний струм без жодного опору при дуже низьких температурах.

5. Темна матерія залишається однією з найбільших загадок сучасної космології, оскільки її вплив можна спостерігати через гравітаційні взаємодії, але вона невидима для телескопів.

10. Answer the questions to the text?

1. What principles do quantum computers utilize to perform computations beyond the capabilities of classical computers?

2. How does electrodynamics extend the study of electromagnetism?

3. What does the kinetic theory describe in terms of particle behavior?

4. What is the focus of crystallography in condensed matter physics?

5. How are gravitational waves generated according to the general theory of relativity?

6. What defines a phase transition in the context of thermodynamics?

7. What is the significance of the cosmic microwave background in cosmology?
8. What does the theoretical framework of supersymmetry propose in particle physics?
9. How has the discovery of superconductivity impacted the development of advanced materials?
10. What role do phonons play in the study of thermal conductivity in materials?
- 11. Write a short summary of the text (See the scheme in the Information File – Ex. 11, P. 16) and be ready to present it.**

S P E A K I N G

1. Guidelines for Discussion:

1. Explore the Evolution of Quantum Mechanics:

Discuss the historical development of quantum mechanics and its revolutionary impact on the understanding of the microscopic world. Highlight key principles like wave-particle duality, superposition, and entanglement.

2. Analyze the Implications of Electrodynamics:

Examine how electrodynamics extends the study of electromagnetism to dynamic situations. Discuss its applications in modern communication technologies and the significance of electromagnetic waves.

3. Investigate the Role of Statistical Mechanics:

Delve into the importance of statistical mechanics in bridging the microscopic and macroscopic worlds. Discuss how it describes the thermodynamic properties of systems and its applications in understanding phase transitions.

4. Evaluate the Discoveries in Condensed Matter Physics:

Discuss the advancements in condensed matter physics, focusing on phenomena like superconductivity and the development of advanced materials. Explore how these discoveries have impacted technology and materials science.

5. Understand the Contributions of Cosmology:

Explore the field of cosmology and its investigation into the large-scale structure and evolution of the universe. Discuss key concepts such as the cosmic microwave background, dark matter, and dark energy.

2. Translate the following text into English:

a) Express the main idea of the text in one sentence

b) Write a short summary of the text in English

Фізика є основною наукою, що досліджує фундаментальні закони та принципи, які керують всесвітом. Ця галузь охоплює вивчення різних явищ, від руху та взаємодії макроскопічних об'єктів до поведінки субатомних частинок. Основи фізики заклали такі вчені, як Ісаак Ньютон, Альберт Ейнштейн і Макс Планк, чії роботи сформували базис класичної та сучасної фізики.

Одним із ключових понять у фізиці є енергія, яка може проявлятися у різних формах, таких як кінетична, потенційна, теплова та електромагнітна. Вивчення енергії та її перетворень лежить в основі багатьох фізичних теорій і законів, таких як закони збереження енергії та закони термодинаміки. Ці принципи мають широке застосування у повсякденному житті та науці, включаючи техніку, енергетику та медицину.

Іншим важливим аспектом фізики є вивчення матерії та її властивостей. Фізики досліджують структуру атомів, молекул і твердих тіл, що дозволяє краще розуміти матеріали та їхні властивості. Це сприяє розвитку нових технологій та матеріалів, які використовуються в промисловості, електроніці та нанотехнологіях.

Сучасна фізика також вивчає фундаментальні сили, які керують взаємодією між частинками. До них належать гравітація, електромагнетизм, слабка та сильна

ядерна взаємодія. Дослідження цих сил допомагає зрозуміти структуру та еволюцію всесвіту, від атомних ядер до галактик.

Таким чином, фізика є надзвичайно багатогранною наукою, яка постійно розширює наші знання про навколишній світ та його закони. Вона поєднує теоретичні дослідження з експериментальними спостереженнями, відкриваючи нові горизонти для наукового прогресу та технологічних інновацій.

Text

1.1.* Read and translate the following text. Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Exploring the Large Hadron Collider: Unveiling the Mysteries of the Universe

The Large Hadron Collider (LHC) is the world's most powerful particle accelerator, located at the European Organization for Nuclear Research (CERN) near Geneva, Switzerland. This colossal machine, with a circumference of 27 kilometers (about 17 miles), is buried underground and operates at temperatures colder than outer space.

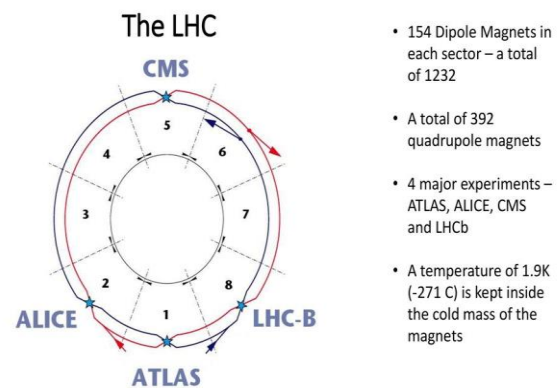
The primary goal of the LHC is to explore the fundamental particles and forces that make up our universe. By accelerating protons and heavy ions to nearly the speed of light and then colliding them, scientists can recreate conditions similar to those just after the Big Bang. These high-energy collisions allow physicists to study particles like the Higgs boson, which was discovered at the LHC in 2012 and helps explain how other particles acquire mass.

One of the key experiments at the LHC is the ATLAS detector, which is designed to observe a wide range of particles and phenomena produced by the collisions. Another important experiment is the CMS (Compact Muon Solenoid) detector, which focuses on

measuring the properties of the Higgs boson and searching for signs of new physics beyond the Standard Model.

The LHC also plays a crucial role in the search for dark matter, a mysterious substance that makes up about 27% of the universe but has not yet been directly detected. By analyzing the data from the collisions, scientists hope to uncover clues about the nature of dark matter and its interactions with ordinary matter.

In addition to its scientific goals, the LHC is a marvel of engineering and technology. Thousands of magnets, including 1232 dipole magnets and 392 quadrupole magnets, are used to steer and focus the particle beams around the accelerator ring. These magnets operate at superconducting temperatures, requiring a sophisticated cooling system that uses liquid helium to maintain the necessary conditions. The LHC continues to push the boundaries of our understanding of the universe, providing valuable insights into the fundamental building blocks of matter and the forces that govern their interactions. As research progresses, the LHC will remain at the forefront of particle physics, helping to unlock the secrets of the cosmos.



1.2* Comprehension Questions:

- What is the primary goal of the LHC, and how do scientists achieve it?
- Describe the role of the ATLAS and CMS detectors at the LHC.
- Why are superconducting magnets important for the operation of the LHC?

1.3* Vocabulary and Terminology:

- Define the following terms: particle accelerator, Higgs boson, dipole magnet, quadrupole magnet.
- Translate the key terms into your native language and use them in sentences.

1.4* Summarize the text about the LHC in your own words in 5-6 sentences.

1.5* Discussion Prompts:

Discuss the potential implications of discovering new particles at the LHC. How might these discoveries impact our understanding of the universe?

Debate the ethical considerations of using such advanced technology and the significant resources required for experiments like those conducted at the LHC.

1.6* Creative Writing:

Imagine you are a scientist working at CERN. Write a diary entry describing a day in your life and the excitement of working on groundbreaking experiments at the LHC.

UNIT 4

QUANTUM MECHANICS AND ITS APPLICATIONS

TEXT

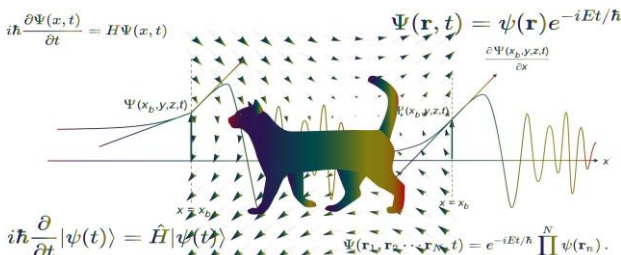
Unlocking the Mysteries of the Subatomic World

1. a) Read and translate the text using the dictionary:

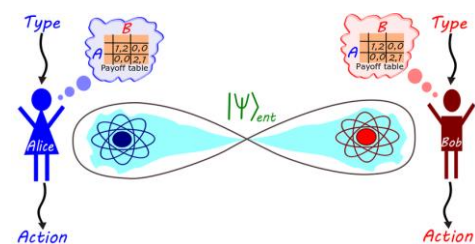
Quantum mechanics is a fundamental branch of physics that explores the behavior of matter and energy at the atomic and subatomic levels. This field has revolutionized our understanding of the universe, revealing a realm where particles can exist in multiple states simultaneously, and interactions occur in ways that defy classical logic.

Key Concepts in Quantum Mechanics

1. Superposition: One of the most intriguing principles of quantum mechanics is superposition, which states that particles, such as electrons, can exist in multiple states at once. It is only when a measurement is made that the particle "collapses" into a definite state.


$$i\hbar \frac{\partial \Psi(x,t)}{\partial t} = H\Psi(x,t)$$
$$\Psi(\mathbf{r},t) = \psi(\mathbf{r})e^{-iEt/\hbar}$$
$$\frac{\partial \Psi(x_0,y,z,t)}{\partial x}$$
$$\Psi(x_0,y,z,t)$$
$$i\hbar \frac{\partial}{\partial t} |\psi(t)\rangle = \hat{H} |\psi(t)\rangle$$
$$\Psi(\mathbf{r}_1, \mathbf{r}_2, \dots, \mathbf{r}_N, t) = e^{-iEt/\hbar} \prod_{n=1}^N \psi(\mathbf{r}_n)$$

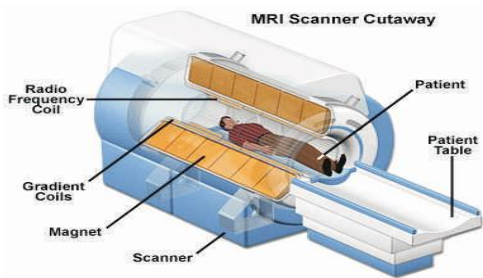
2. Entanglement: Another fascinating phenomenon is quantum entanglement,



where two or more particles become interconnected in such a way that the state of one particle instantly influences the state of the other, regardless of the distance between them. This "spooky action at a distance," as Albert Einstein famously described it, has profound implications for communication and information processing.

eavesdrop on the communication can be detected, providing unparalleled security for sensitive information.

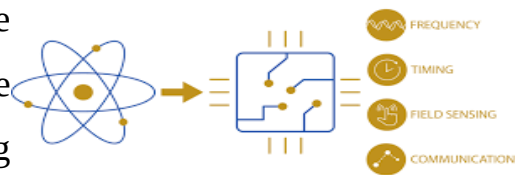
4. Medical Imaging: Quantum mechanics has also played a crucial role in the



development of advanced medical imaging techniques such as Magnetic Resonance Imaging (MRI). By understanding the interactions between atomic nuclei and magnetic fields, MRI provides detailed images of the body's internal structures, aiding in the diagnosis and treatment of various medical conditions.

5. Quantum Sensors: Quantum sensors

leverage the sensitivity of quantum states to measure physical quantities with exceptional precision. These sensors are used in various applications, including navigation, climate monitoring, and fundamental research in physics.



Future Prospects and Research: *The field of quantum mechanics continues to be a hotbed of research and innovation. Scientists are exploring new ways to harness quantum phenomena for practical applications, such as developing more stable qubits for quantum computers and creating new materials with unique properties. The potential for breakthroughs in this field remains immense, promising to unlock new technologies and deepen our understanding of the universe.*

In conclusion, quantum mechanics is a transformative field that challenges our conventional understanding of the physical world. Its applications span across various industries, driving technological advancements and opening new frontiers in science and engineering. As research progresses, the impact of quantum mechanics on our lives is bound to grow, ushering in a new era of innovation and discovery.

b) Translate the italicized paragraphs into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

2. Synonym Groups for Physics Vocabulary:

Select 5 key terms from the text. For each term, create a list of 2 to 6 synonyms that capture the same or similar meanings within the context of physics. Below are examples to learn and to guide you.

1. **Superposition** — Overlapping — Coexistence
2. **Sensitive** — Precise — Accurate — Fine-tuned - Delicate
3. **Secure** — Safe — Protected — Reliable - Guarded
4. **Semiconductors** - Electronic Components - Conductive Materials
5. **Explore** — Investigate — Examine — Study — Research
6. **Revolutionize** — Transform — Innovate — Change — Modernize
7. **Leverage** — Utilize — Employ — Use — Apply
8. **Perform** — Execute — Conduct - Carry out — Implement
9. **Fundamental** — Essential — Basic — Primary — Core
10. **Cutting-edge** — Advanced — Innovative — State-of-the-art - Leading-edge

3. Using the dictionary transcribe and translate the key words:

Word	Transcription	Translation
realm		
simultaneously		
intriguing		
measurement		
Einstein		

exhibit		
leverage		
diodes		
circuit		
entangled		
crucial		
diagnosis		
sensitivity		
qubit		
advancement		

4. Match the words with their definition:

1. Quantum Mechanics	a) A phenomenon in quantum mechanics where two or more particles become interconnected in such a way that the state of one particle instantly affects the state of the other, regardless of the distance between them.
2. Superposition	b) The basic units of quantum information, analogous to bits in classical computing, but capable of representing 0, 1, or any quantum superposition of these states.
3. Entanglement	c) A principle of quantum mechanics where a particle can exist in multiple states simultaneously until it is measured, at which point it collapses into one definite state.

4. Wave-Particle Duality	d) A field of computing that leverages the principles of quantum mechanics, such as superposition and entanglement, to perform computations that are far more efficient than those possible with classical computers.
5. Quantum Computing	e) Devices that utilize quantum states to measure physical quantities with exceptional precision, used in applications such as navigation, climate monitoring, and fundamental physics research.
6. Semiconductors	f) A concept in quantum mechanics that suggests particles, such as electrons, can exhibit both wave-like and particle-like properties depending on the experimental setup.
7. Quantum Cryptography	g) A technique that uses principles of quantum mechanics to secure communication by allowing the detection of any eavesdropping attempts, thus providing unparalleled security.
8. Qubits	h) A medical imaging technique that uses the principles of quantum mechanics to create detailed images of the internal structures of the body by measuring the interactions between atomic nuclei and magnetic fields.
9. Magnetic Resonance Imaging (MRI)	i) A fundamental branch of physics that studies the behavior of matter and energy at the atomic and subatomic levels, revealing phenomena such as superposition and entanglement.

10. Quantum Sensors	j) Materials that have electrical conductivity between that of conductors and insulators. They are the foundation of modern electronics, including transistors and diodes.
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5. Give English equivalents to the meanings of the following words and word combinations:

передові концепції	
сучасні відкриття	
новаторські досягнення в науці	
використовувати важелі	
принципи суперпозиції	
виконувати обчислення	
взаємодія зарядів і струмів	
хвилеводи і антени	
передові системи зв'язку	
ентропія	
фазові переходи	
поведінка газів, рідин і твердих тіл	
фізика конденсованого середовища	
твердий і рідкий стани речовини	
надпровідність	
масштабна структура	

походження, склад і доля Всесвіту	
теорія великого вибуху	
фізика високих енергій	
Великий адронний колайдер	
перетинатися з	
міждисциплінарні напрямки досліджень	
інноваційні технології	

6. Find synonyms to the words:

1. Behavior -
2. Phenomenon -
3. Measurement -
4. Reveal -
5. Understand -
6. Exhibit -
7. Advanced -
8. Secure -
9. Exceptional -
10. Intriguing -

7. Choose the correct answer:

1. What is superposition in quantum mechanics?
 - A) The principle that particles can exist in multiple states simultaneously until measured
 - B) The concept that particles travel in straight lines
 - C) The idea that particles have fixed positions

- D) The theory that particles do not interact with each other
2. What is quantum entanglement?
- A) The phenomenon where particles travel in circles
 - B) The interaction between particles and magnetic fields
 - C) The state where two or more particles instantly influence each other regardless of distance
 - D) The movement of particles in a wave-like manner
3. Which experiment best illustrates wave-particle duality?
- A) Double-slit experiment
 - B) Photoelectric effect experiment
 - C) Rutherford's gold foil experiment
 - D) Stern-Gerlach experiment
4. Which of the following is an application of quantum computing?
- A) Solving complex problems in cryptography
 - B) Enhancing photographic resolution
 - C) Improving fuel efficiency in cars
 - D) Analyzing weather patterns
5. What are semiconductors used for in modern electronics?
- A) Storing thermal energy
 - B) Building transistors and integrated circuits
 - C) Generating nuclear power
 - D) Detecting gravitational waves
6. What does quantum cryptography provide?
- A) Enhanced speed of data transmission
 - B) Highly secure communication channels
 - C) Efficient data compression
 - D) Improved satellite navigation
7. What are qubits in quantum computing?

- A) Traditional binary units of information
 - B) Quantum units capable of representing 0, 1, or a superposition of these states
 - C) Mechanical switches in classical computers
 - D) Elements that store optical data
8. How does Magnetic Resonance Imaging (MRI) utilize quantum mechanics?
- A) By creating magnetic fields to measure atomic nuclei interactions
 - B) By generating electrical currents to monitor brain activity
 - C) By using sound waves to image internal structures
 - D) By employing lasers to detect blood flow
9. Which is the best way to translate the following sentence:
- Quantum mechanics reveals a realm where particles can exist in multiple states simultaneously.*
- A) Квантова механіка відкриває область, де частинки можуть одночасно перебувати в декількох станах.
 - B) Квантова механіка показує світ, де частинки можуть існувати одночасно в різних станах.
 - C) Квантова механіка розкриває царину, де частинки можуть одночасно бути в декількох станах.
 - D) Квантова механіка демонструє, що частинки можуть одночасно бути в різних місцях.
10. Which is the best way to translate the following sentence:
- Quantum entanglement allows particles to instantaneously affect each other regardless of distance.*
- A) Квантова заплутаність дозволяє частинкам миттєво впливати один на одного незалежно від відстані між ними.
 - B) Квантова заплутаність дозволяє частинкам безпосередньо впливати одна на одну незалежно від відстані між ними.

C) Квантова запутаність дозволяє частинкам миттєво взаємодіяти один з одним незалежно від відстані між ними.

D) Квантова запутаність дозволяє частинкам миттєво впливати одна на одну незалежно від їхньої відстані.

8. Translate the following sentences into Ukrainian:

1. The phenomenon of quantum entanglement allows particles to remain connected and influence each other instantaneously over vast distances.

2. Researchers are leveraging quantum computing to solve complex problems that are beyond the capabilities of classical computers.

3. Wave-particle duality reveals that particles like electrons can exhibit both wave-like and particle-like behaviors depending on the experimental conditions.

4. Advances in medical imaging technologies, such as MRI, are heavily reliant on principles derived from quantum mechanics.

5. Semiconductors play a crucial role in modern electronics, thanks to our understanding of electron behavior in different materials.

9. Translate the following sentences into English:

1. Принцип квантової суперпозиції дозволяє частинкам перебувати в декількох станах одночасно до моменту вимірювання.

2. Квантові комп'ютери можуть вирішувати надскладні задачі, які є недосяжними для класичних комп'ютерів.

3. Ефект квантової запутаності забезпечує миттєвий вплив одного стану частинки на інший, незалежно від відстані між ними.

4. Хвильова природа частинок підтверджується через інтерференційні візерунки у досліді з двома щілинами.

5. Сучасна медична візуалізація, така як МРТ, ґрунтується на принципах квантової механіки для створення детальних зображень внутрішніх структур тіла.

10. Answer the questions to the text?

1. What fundamental principles does quantum mechanics explore at the atomic and subatomic levels?
2. How does the principle of superposition impact the state of a particle until it is measured?
3. What is quantum entanglement, and how does it influence interconnected particles?
4. Describe the concept of wave-particle duality and its significance in quantum mechanics.
5. How do quantum computers utilize superposition and entanglement to perform complex computations?
6. What role do semiconductors play in modern electronics, and how is this related to quantum mechanics?
7. Explain the benefits of quantum cryptography in securing communication channels.
8. How has quantum mechanics contributed to advancements in medical imaging techniques like MRI?
9. What makes quantum sensors exceptionally precise, and what are some of their applications?
10. Discuss the potential future prospects and research areas in the field of quantum mechanics.

11. Write a short summary of the text (See the scheme in the Information File – Ex. 11, P. 16) and be ready to present it.

S P E A K I N G

1. Guidelines for Discussion:

1. Discuss the Principles of Superposition and Entanglement:

Explore the implications of superposition and entanglement in quantum mechanics. How do these principles challenge classical notions of particle states and interactions?

2. Examine the Applications of Quantum Computing:

Evaluate the potential of quantum computing in solving complex problems. What are some real-world applications, and how might they revolutionize industries such as cryptography, optimization, and material science?

3. Analyze the Impact of Quantum Mechanics on Modern Electronics:

Discuss the role of quantum mechanics in the development of semiconductors and other electronic components. How has our understanding of electron behavior in materials led to technological advancements?

4. Explore the Advancements in Medical Imaging:

Investigate how principles of quantum mechanics have contributed to medical imaging technologies like MRI. What are the benefits of these advancements for diagnosis and treatment in healthcare?

5. Evaluate the Precision of Quantum Sensors:

Examine the development and applications of quantum sensors. How do these sensors leverage quantum states for high-precision measurements, and in what fields are they particularly useful?

2. Translate the following text into English:

a) Express the main idea of the text in one sentence

b) Write a short summary of the text in English

Новітні технології та квантова механіка

Квантова механіка є важливою галуззю фізики, що досліджує фундаментальні властивості матерії та енергії на атомному і субатомному рівнях.

Вона знаходить своє відображення у багатьох сучасних технологіях, відкриваючи нові горизонти для інновацій і досліджень.

Одним з найцікавіших напрямків застосування квантової механіки є розробка квантових комп'ютерів. Вони використовують квантові біти, або кубіти, які мають здатність перебувати в стані суперпозиції, що дозволяє здійснювати обчислення зі значно вищою швидкістю порівняно з класичними комп'ютерами. Квантові комп'ютери мають потенціал змінити криптографію, оптимізацію логістичних систем та моделювання складних біологічних процесів.

Квантова криптографія є ще однією важливою галуззю, де принципи квантової механіки знаходять своє застосування. Використовуючи заплутані частинки, квантова криптографія забезпечує надзвичайно безпечний обмін інформацією, оскільки будь-яка спроба перехоплення даних негайно виявляється.

Сучасні досягнення в галузі нанотехнологій також значною мірою ґрунтуються на квантовій механіці. Розробка нових матеріалів, таких як графен, відкриває нові можливості для створення гнучкої електроніки, високочутливих сенсорів і енергоефективних пристроїв. Такі матеріали мають унікальні властивості, які змінюють підхід до інженерних рішень у різних галузях.

Нарешті, квантові сенсори демонструють високу точність у вимірюваннях фізичних величин. Вони знаходять застосування у навігаційних системах, моніторингу кліматичних змін та фундаментальних дослідженнях у фізиці. Завдяки квантовим сенсорам, ми можемо отримувати дані з надзвичайною точністю, що відкриває нові горизонти для наукових досліджень.

EXTENDED READING*

1.1* Read and translate the following texts Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Text 1

Quantum Sensors: Redefining Precision in Measurement

Quantum sensors represent a cutting-edge technology that leverages the principles of quantum mechanics to achieve unprecedented accuracy in measuring various physical quantities. These sensors capitalize on the unique properties of quantum states, such as superposition and entanglement, to detect minute changes in the environment with exceptional precision.



One of the most notable applications of quantum sensors is in the field of metrology, where they are used to redefine standard units of measurement. For instance, atomic clocks, which are a type of quantum sensor, utilize the vibrations of atoms to keep time with extraordinary accuracy. This precision is crucial for global positioning systems (GPS), telecommunications, and even financial transactions that rely on precise timekeeping.

In the medical field, quantum sensors have revolutionized imaging technologies. Techniques like magnetic resonance imaging (MRI) benefit from the high sensitivity of quantum sensors to detect the faintest magnetic fields produced by atomic nuclei in the body. This allows for detailed and non-invasive imaging of soft tissues, aiding in the early diagnosis and treatment of various medical conditions.

Quantum sensors are also making significant strides in environmental monitoring. They can measure gravitational fields with incredible accuracy, which is essential for applications such as detecting underground resources, monitoring sea level changes, and studying geological processes. Additionally, these sensors can detect changes in electric and magnetic fields, providing valuable data for climate research and atmospheric studies.

Another exciting application is in navigation systems. Quantum accelerometers and gyroscopes offer highly precise measurements of movement and orientation, enhancing the accuracy of inertial navigation systems used in submarines, aircraft, and autonomous vehicles. This precision ensures reliable navigation in environments where GPS signals may be unavailable or unreliable.

Research in quantum sensors continues to advance, with scientists exploring new materials and techniques to enhance their capabilities. For example, the development of diamond-based quantum sensors has shown promise in detecting single molecules and studying biological processes at the nanoscale. These advancements hold the potential to transform various industries, from healthcare to defense, by providing tools that offer unparalleled sensitivity and accuracy.

In summary, quantum sensors are redefining the standards of precision measurement across multiple fields. Their ability to exploit quantum phenomena for high-accuracy detection opens up new possibilities for scientific research, technological innovation, and practical applications, marking a new era of precision in the measurement of physical quantities.

1.2* Comprehension Questions:

1. What fundamental principles do quantum sensors leverage to achieve high precision in measurements?
2. How do atomic clocks, as a type of quantum sensor, contribute to GPS and telecommunications?
3. Explain how quantum sensors are used in magnetic resonance imaging (MRI) and their benefits for medical diagnostics.
4. In what ways do quantum sensors enhance environmental monitoring and geological studies?
5. Describe the role of quantum accelerometers and gyroscopes in improving navigation systems.

1.3* Vocabulary and Terminology:

a) Define the following terms	b) Match the terms to their definitions
1. Quantum State	a) The study of measurement and its application.
2. Superposition	b) The ability of a particle to exist in multiple states simultaneously.
3. Entanglement	c) A highly sensitive device used to measure physical quantities with precision.
4. Metrology	d) A technology used for highly accurate positioning and navigation.
5. Inertial Navigation Systems	e) The phenomenon where particles become interconnected and influence each other instantaneously.

1.4* Write a brief summary of the text in your own words in 5-6 sentences.

1.5* Discussion Prompts:

1. Discuss the potential impact of quantum sensors on future technological advancements. How might they change industries such as healthcare, defense, and environmental science?

2. Explore the ethical considerations of using highly sensitive quantum sensors for surveillance and data collection. What measures can be taken to ensure privacy and security?

3. Reflect on the challenges scientists face in developing and implementing quantum sensors. What are some potential solutions to these challenges?

4. Debate the importance of government funding and support for research in quantum technologies. How can public and private sectors collaborate to drive innovation in this field?

5. Analyze the role of interdisciplinary collaboration in the development of quantum sensors. How do physicists, engineers, and other scientists work together to advance this technology?

1.6* Research and Presentation:

Conduct research on the current advancements in quantum sensors. Focus on one specific application, such as medical imaging, environmental monitoring, or navigation systems. Prepare a detailed presentation explaining how quantum sensors are being utilized in this field, and discuss their benefits and challenges

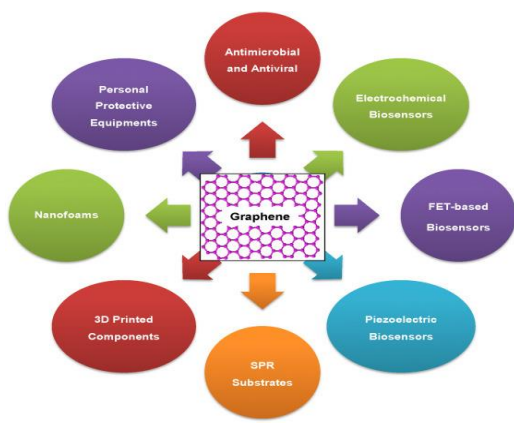
Text 2

2.1* Read and translate the following texts Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Innovative Materials: Unlocking the Potential of Graphene

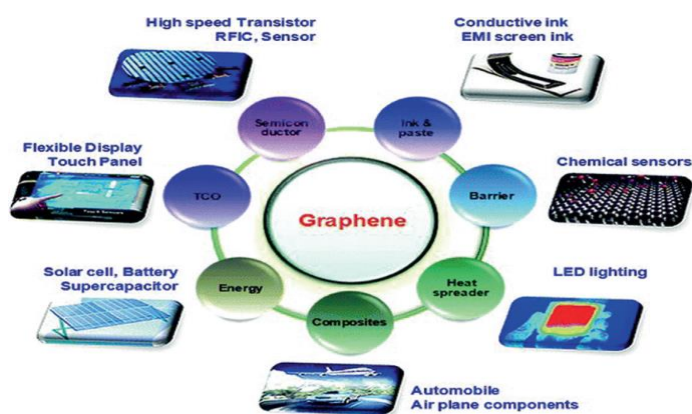
The development of new materials has always been a cornerstone of technological advancement, and graphene stands out as one of the most promising breakthroughs in recent years. This remarkable material, composed of a single layer of carbon atoms arranged in a two-dimensional honeycomb lattice, has captured the attention of scientists and engineers worldwide due to its exceptional properties and diverse applications.

One of the most exciting prospects of graphene lies in the creation of flexible electronics.



Traditional electronic devices, with their rigid components, often face limitations in terms of durability and adaptability. Graphene's extraordinary mechanical strength, combined with its flexibility, opens up new possibilities for bendable and stretchable electronics. Imagine smartphones that can be folded or worn on the wrist, or wearable health monitors that conform seamlessly to the contours of the body. These innovations are no longer confined to the realm of science fiction but are becoming tangible realities thanks to graphene. In addition to flexible electronics, graphene's high electrical conductivity and sensitivity make it an ideal material for developing highly sensitive sensors. These sensors can detect a wide range of physical, chemical, and biological signals with unparalleled precision. For instance, graphene-based sensors can be used to monitor environmental pollutants, detect hazardous gases, or even diagnose diseases through the analysis of biological markers. The versatility and accuracy of graphene sensors hold immense potential for enhancing safety, health, and environmental monitoring. Energy efficiency is another area where graphene demonstrates its transformative capabilities. The material's high surface area and exceptional electrical properties enable the development of advanced energy storage devices, such as supercapacitors and batteries. These graphene-based devices can store and deliver energy more efficiently than their traditional counterparts, leading to longer-lasting batteries for electronic devices and more efficient energy storage solutions for renewable energy systems. The impact of graphene on energy technology could significantly reduce our reliance on fossil fuels and contribute to a more sustainable future.

Research and development in the field of graphene continue to unveil new



applications and possibilities. Scientists are exploring ways to integrate graphene with other materials to create composite structures with enhanced properties. These efforts aim to overcome challenges

related to large-scale production, stability, and cost-effectiveness, paving the way for widespread adoption of graphene-based technologies. In conclusion, the development of graphene and similar innovative materials is revolutionizing various industries, from electronics to energy storage and environmental monitoring. As research progresses, the full potential of graphene will likely be realized, driving a new era of technological innovation and offering solutions to some of the most pressing challenges of our time.

2.2* Comprehension Questions:

1. What are the unique properties of graphene that make it suitable for flexible electronics?
2. How can graphene-based sensors benefit environmental monitoring and health diagnostics?
3. Explain the role of graphene in advancing energy storage devices like super capacitors and batteries.
4. What challenges do scientists face in the large-scale production and cost-effectiveness of graphene-based technologies?
5. Describe how the integration of graphene with other materials can enhance their properties.

2.3* Vocabulary and Terminology:

a) Define the following terms	b) Match the terms to their definitions
1. Graphene	a) The ability to conduct electricity efficiently.
2. Mechanical Strength	b) A material composed of a single layer of carbon atoms arranged in a honeycomb lattice.
3. Electrical Conductivity	c) Devices that store and deliver energy, such

	as batteries and super capacitors.
4. Energy Storage Devices	d) The measure of a material's ability to withstand mechanical stress.
5. Composite Structures	e) Structures made by combining two or more materials to enhance their properties.

2.4* Summarize the text about the Potential of Graphene in your own words in 5-6 sentences.

2.5* Discussion Prompts:

1. Discuss the potential impact of graphene on the future of flexible electronics. What are some possible applications, and how might they change our daily lives?

2. Explore the ethical and environmental considerations of large-scale graphene production. What steps can be taken to ensure sustainable and responsible use of this material?

3. Reflect on the interdisciplinary collaboration required for graphene research and development. How do scientists, engineers, and industry professionals work together to bring graphene-based technologies to market?

4. Debate the importance of government funding and support for research in innovative materials like graphene. How can public and private sectors collaborate to drive progress in this field?

5. Analyze the role of graphene in improving energy efficiency and sustainability. How can graphene-based energy storage devices contribute to reducing our reliance on fossil fuels?

2.6* Research and Presentation:

Conduct research on the latest advancements in graphene-based flexible electronics. Prepare a presentation explaining how these devices work, their benefits, and potential challenges.

UNIT V

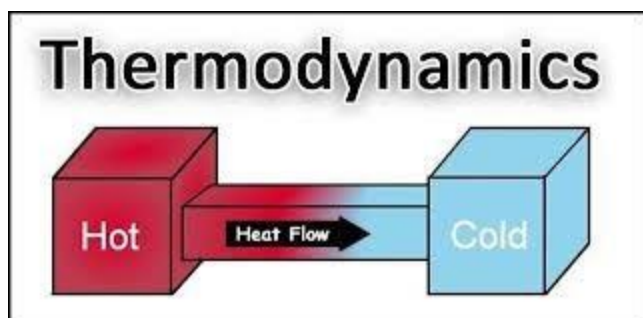
THERMODYNAMICS

TEXT

Thermodynamics: fundamental concepts, properties and relations

1. a) Read and translate the text using the dictionary.

Thermodynamics is a science of the relationships between heat, work, energy and



temperature. It deals with the transfer of energy from one place to another and from one form to another. The key concept is that heat is a form of energy corresponding to a definite amount of mechanical work.

Thermodynamics is not concerned about how and at what rate these energy transformations are carried out. It is based on the initial and final states undergoing the change. It should also be noted that thermodynamics is a macroscopic science. This means that it deals with the bulk system and does not deal with the molecular constitution of matter.

Thermodynamics is classified into the following four branches:

- Classical Thermodynamics
- Statistical Thermodynamics
- Chemical Thermodynamics
- Equilibrium Thermodynamics

Classical Thermodynamics. In classical thermodynamics, the behaviour of matter is analyzed with a macroscopic approach. Units such as temperature and pressure

are taken into consideration, which helps the individuals calculate other properties and predict the characteristics of the matter undergoing the process.

Statistical Thermodynamics. In statistical thermodynamics, every molecule is under the spotlight, i.e. the properties of every molecule and how they interact are taken into consideration to characterize the behaviour of a group of molecules.

Chemical Thermodynamics is the study of how work and heat relate to each other in chemical reactions and in changes of states.

Equilibrium Thermodynamics studies the transformations of energy and matter as they approach the state of equilibrium.

Basic Concepts of Thermodynamics.

***Thermodynamic System** is a specific portion of matter with a definite boundary. The system boundary may be real or imaginary, fixed or deformable. There are three types of systems:*

- ***Isolated System** – An isolated system cannot exchange energy and mass with its surroundings. The universe is considered an isolated system.*
- ***Closed System** – Across the boundary of the closed system, the transfer of energy takes place but the transfer of mass doesn't take place. Refrigerator, compression of gas in the piston-cylinder assembly are examples of closed systems.*
- ***Open System** – In an open system, the mass and energy both may be transferred between the system and surroundings. A steam turbine is an example of an open system.*

A particularly important concept is **thermodynamic equilibrium**. For example, the gas in a cylinder with a movable piston will be at equilibrium if the temperature and pressure inside are uniform and if the restraining force on the piston is just sufficient to keep it from moving. The system can then be made to change to a new state only by an externally imposed change in one of the state functions, such as the temperature by adding heat or the volume by moving the piston. A sequence of one or more such steps connecting different states of the system is called a process. In general, a system is not in

equilibrium as it adjusts to an abrupt change in its environment. For example, when a balloon bursts, the compressed gas inside is suddenly far from equilibrium, and it rapidly expands until it reaches a new equilibrium state. However, the same final state could be achieved by placing the same compressed gas in a cylinder with a movable piston and applying a sequence of many small increments in volume (and temperature), with the system being given time to come to equilibrium after each small increment. Such a process is said to be reversible because the system is at (or near) equilibrium at each step along its path, and the direction of change could be reversed at any point. This example illustrates how two different paths can connect the same initial and final states. The first is irreversible (the balloon bursts), and the second is reversible. The concept of reversible processes is something like motion without friction in mechanics. It represents an idealized limiting case that is very useful in discussing the properties of real systems. Many of the results of thermodynamics are derived from the properties of reversible processes.

Thermodynamic properties are defined as characteristic features of a system, capable of specifying the system's state. Thermodynamic properties may be **extensive** or **intensive**.

- Intensive properties are properties that do not depend on the quantity of matter. Pressure and temperature are intensive properties.
- In the case of extensive properties, their values depend on the mass of the system. Volume, energy, and enthalpy are extensive properties.

As mentioned before, thermodynamics is a branch of physics that studies heat, energy, and their transformations. It explains how energy is transferred between systems and how it affects matter. This study plays a crucial role in everyday life and technology, from engines and refrigerators to weather patterns and biological processes. It helps us understand how energy flows and how to use it efficiently.

b) Translate the italicized paragraph into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

2. Synonyms in Physics Vocabulary.

a) Below is a list of physics-related words from the text. Match each word with its closest synonym.

1. Transformation

- a) Transfer
- b) Conversion
- c) Conduction

2. Macroscopic

- a) Large-scale
- b) Atomic
- c) Invisible

3. Interaction

- a) Movement
- b) Connection
- c) Isolation

4. Boundary

- a) Limit
- b) Surface
- c) Mass

5. Characteristic

- a) Force
- b) Property
- c) Energy

b) Fill in the blanks with the correct synonym:

1. The _____ (conversion / isolation / pressure) of energy from one form to another is a key principle of thermodynamics.
2. In classical thermodynamics, we analyze matter on a _____ (microscopic / large-scale / molecular) level.
3. A closed system has a fixed _____ (volume / boundary / density) that separates it from its surroundings.
4. Heat _____ (transfer / expansion / storage) occurs when thermal energy moves from a hotter object to a colder one.
5. A system reaches _____ (motion / equilibrium / reaction) when all its properties remain constant over time.
6. The energy _____ (conversion / isolation / storage) process allows one form of energy to change into another.
7. Temperature and pressure are _____ (intensive / extensive / molecular) properties because they do not depend on the system's mass.
8. The law of energy conservation states that energy cannot be _____ (created / transformed / destroyed), only converted from one form to another.
9. A gas expands when its _____ (volume / mass / boundary) increases due to heat absorption.
10. In thermodynamics, a process that happens spontaneously and cannot be reversed is called _____ (reversible / irreversible / periodic).

3. Using the dictionary transcribe and translate the key words and words combinations:

<i>Word</i>	<i>Transcription</i>	<i>Translation</i>
heat		
transfer of energy		

molecular constitution		
pressure		
compression		
thermodynamic equilibrium		
reversible		
irreversible		
volume		
friction		
motion		
enthalpy		
mass		
extensive		
intensive		
undergo		
state		
isolation		
interaction		
boundary		
energy conservation		

4. Match the words with their definitions:

- 1) Thermodynamics ____
- 2) Macroscopic ____
- 3) Thermodynamic system ____
- 4) Equilibrium ____
- 5) Closed system ____

- 6) Intensive property _____
- 7) Reversible process _____
- 8) Isolated system _____
- 9) Extensive property _____
- 10) Irreversible process _____

- a) A specific portion of matter with a defined boundary.
- b) A property that does not depend on the amount of matter in a system.
- c) The study of heat, work, and energy transformations.
- d) The state where all properties of a system remain stable unless disturbed.
- e) A property that depends on the amount of matter in a system, such as volume or energy.
- f) The study of matter and energy on a large-scale level, without focusing on molecules.
- g) A process that occurs in such small steps that the system remains in equilibrium at each stage.
- h) A system that cannot exchange energy or mass with its surroundings.
- i) A system where energy is transferred, but mass remains constant.
- j) A process that happens spontaneously and cannot return to its original state without external influence.

5. Give English equivalents to the meanings of the following words and word combinations.

Термодинаміка	
Теплота	
Робота	
Енергія	
Передача енергії	

Температура	
Термодинамічна система	
Рівновага	
Макроскопічний підхід	
Статистична термодинаміка	
Хімічна термодинаміка	
Термодинамічні процеси	
Відкрита система	
Ізольована система	
Закрита система	
Тиск	
Об'єм	
Реверсивний процес	
Ірреверсивний процес	
Термодинаміка рівноваги	

6. Read the statements below and decide whether they are true (T) or false (F) based on the text. If a statement is false, correct it.

1. ____ Thermodynamics studies the relationships between heat, work, energy, and temperature.
2. ____ Thermodynamics focuses on the microscopic properties of individual molecules.
3. ____ There are three main branches of thermodynamics.
4. ____ An isolated system can exchange energy but not mass with its surroundings.
5. ____ A closed system allows both mass and energy transfer across its boundaries.
6. ____ A reversible process occurs in small steps, keeping the system near equilibrium at all times.
7. ____ Temperature and pressure are examples of extensive properties.

8. ____ A steam turbine is an example of an open system.
9. ____ Equilibrium thermodynamics studies systems that are far from equilibrium.
10. ____ The first law of thermodynamics states that energy cannot be created or destroyed, only transformed.

7. Choose the correct answer:

1. What does thermodynamics study?
 - A) Only the behavior of gases.
 - B) The relationships between heat, work, energy, and temperature.
 - C) The movement of electrical charges.
 - D) The motion of objects in space.
2. Which of the following is not a branch of thermodynamics?
 - A) Classical Thermodynamics.
 - B) Chemical Thermodynamics.
 - C) Mechanical Thermodynamics.
 - D) Statistical Thermodynamics.
3. Which type of system does not exchange mass or energy with its surroundings?
 - A) Open system.
 - B) Closed system.
 - C) Isolated system.
 - D) Equilibrium system.
4. What is an example of a closed system?
 - A) A steam turbine.
 - B) A refrigerator.
 - C) A balloon bursting.
 - D) The universe.
5. What happens in a reversible process?
 - A) The system stays in equilibrium at each step.

- B) The system undergoes an irreversible transformation.
 - C) The process occurs suddenly and cannot be reversed.
 - D) Energy is destroyed.
6. Which property depends on the amount of matter in a system?
- A) Pressure.
 - B) Temperature.
 - C) Volume.
 - D) Density.
7. What is required for a system to reach thermodynamic equilibrium?
- A) Constant energy input.
 - B) Equal temperature and pressure throughout the system.
 - C) An isolated boundary.
 - D) Rapid energy transfer.
8. What happens when a balloon bursts?
- A) The system remains in equilibrium.
 - B) The process is reversible.
 - C) The gas expands rapidly and reaches a new equilibrium state.
 - D) The balloon remains intact.
9. Which of the following is the best way to translate the sentence?

Thermodynamics does not focus on the specific mechanisms or rates of energy transformations.

A) Термодинаміка не зосереджується на конкретних механізмах або швидкості перетворень енергії.

B) Термодинаміка зосереджується на конкретних механізмах або швидкості перетворень енергії.

C) Термодинаміка вивчає конкретні механізми або швидкість перетворень енергії.

D) Термодинаміка функціонує на основі конкретних механізмів або швидкості перетворень енергії.

10. The word combination *irreversible process* in the text is translated into Ukrainian as

- A) зворотній процес.
- B) незворотній процес.
- C) непостійний процес.
- D) термодинамічний процес.

8. Translate the following sentences into Ukrainian:

1. Thermodynamics is a fundamental branch of physics that examines how heat, work, and energy interact within different systems, focusing on their transformations rather than the specific mechanisms behind these changes.

2. Although thermodynamics does not analyze the microscopic behavior of individual molecules, statistical thermodynamics provides a bridge between macroscopic properties and molecular interactions, allowing for a deeper understanding of energy distribution.

3. The classification of thermodynamic systems – isolated, closed, and open – is based on their ability to exchange mass and energy with their surroundings, with the universe itself being considered an ideal example of an isolated system.

4. A key principle in thermodynamics is equilibrium, which is achieved when a system's temperature, pressure, and other properties remain uniform unless influenced by external forces, as seen in a gas confined within a cylinder with a movable piston.

5. Reversible processes, which occur in infinitesimally small steps maintaining near-equilibrium conditions, serve as an idealized model in thermodynamics, contrasting with irreversible processes that involve rapid changes and energy dissipation.

9. Translate the following sentences into English:

1. Термодинаміка – це розділ фізики, що вивчає взаємозв'язок між теплотою, роботою, енергією та температурою, а також способи їхнього перетворення.

2. Основним принципом термодинаміки є збереження енергії, згідно з яким енергія лише змінює свою форму.

3. Термодинамічні системи поділяються на ізольовані, закриті та відкриті залежно від того, чи обмінюються вони масою та енергією з навколишнім середовищем.

4. Реверсивні процеси відбуваються через надзвичайно малі зміни стану системи, дозволяючи підтримувати рівновагу на кожному етапі, що є важливим для ідеалізованих моделей у фізиці.

5. Термодинамічні властивості поділяються на інтенсивні, такі як температура і тиск, які не залежать від маси системи, та екстенсивні, наприклад, об'єм і енергія, значення яких змінюється разом із розміром системи.

10. Answer the questions to the text.

1. What is the main focus of thermodynamics?
2. How does thermodynamics define heat in relation to energy?
3. What are the four main branches of thermodynamics?
4. How does classical thermodynamics differ from statistical thermodynamics?
5. What are the three types of thermodynamic systems, and how do they differ?
6. Why is the universe considered an isolated system?
7. What is thermodynamic equilibrium, and how can it be achieved?
8. What is the difference between a reversible and an irreversible process?
9. Which properties are classified as intensive and which as extensive?
10. Why is thermodynamics considered a macroscopic science?

11. Write a short summary of the text “Thermodynamics: fundamental concepts, properties and relations” (See the scheme in the Information File – ex. 11 p. 16) and be ready to present it.

SPEAKING

1. Guidelines for Discussion:

1. **Discuss the practical applications of thermodynamics in everyday life.** How do refrigerators, car engines, and air conditioners use thermodynamic principles?
2. **Compare and contrast the three types of thermodynamic systems.** In what situations would an open, closed, or isolated system be most relevant?
3. **Debate the significance of reversible vs. irreversible processes.** Why are reversible processes considered ideal, and how do they differ from real-world processes?
4. **Analyze the role of equilibrium in thermodynamics.** How does a system reach equilibrium, and why is it important in scientific and industrial applications?
5. **Explore the connection between classical and statistical thermodynamics.** How does statistical thermodynamics help explain macroscopic thermodynamic laws?

2. Translate the following text into English:

- a) Express the main idea of the text in one sentence.
- b) Write a short summary of the text in English.

Термодинаміка – це розділ фізики, який вивчає тепло, енергію та їхні перетворення. Вона допомагає зрозуміти, як енергія передається між об'єктами та як змінюється стан речовини. Ця наука важлива для багатьох галузей, таких як енергетика, техніка, хімія та навіть біологія.

Термодинаміка має чотири основні закони.

Нульовий закон пояснює, що якщо два тіла мають однакову температуру з третім тілом, то вони також мають однакову температуру між собою. Це допомагає визначати температуру за допомогою термометрів.

Перший закон говорить, що енергія не зникає і не з'являється з нічого, а лише переходить з однієї форми в іншу. Наприклад, у двигуні автомобіля хімічна енергія пального перетворюється на механічну роботу.

Другий закон пояснює, що тепло завжди переходить від гарячого тіла до холодного, а не навпаки. Також він вводить поняття ентропії – показника неупорядкованості системи, який завжди зростає.

Третій закон стверджує, що при температурі абсолютного нуля рух молекул припиняється і ентропія ідеального кристала стає нульовою.

У термодинаміці існує три основні типи систем.

Ізольована система не може обмінюватися ні енергією, ні масою (наприклад, Всесвіт). *Закрита система* може обмінюватися енергією, але не масою (наприклад, каструля з кришкою). *Відкрита система* може обмінюватися як енергією, так і масою (наприклад, киплячий чайник, з якого виходить пара).

Термодинамічні процеси можуть бути *реверсивні*, коли відбуваються повільно і система залишається близькою до рівноваги (наприклад, стиснення газу у поршні) та *нереверсивні* – відбуваються швидко, і система втрачає рівновагу (наприклад, вибух повітряної кульки).

Термодинаміка використовується в багатьох сферах: в енергетиці – для роботи двигунів, турбін, холодильників; у хімії – для аналізу хімічних реакцій; у біології – для пояснення обміну речовин в організмі; у метеорології – для вивчення погоди та клімату.

Термодинаміка допомагає зрозуміти, як працює енергія у природі та техніці. Вона пояснює основні принципи теплових процесів і використовується у багатьох сферах нашого життя.

EXTENDED READING *

1.1* Read and translate the following text. Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Text 1

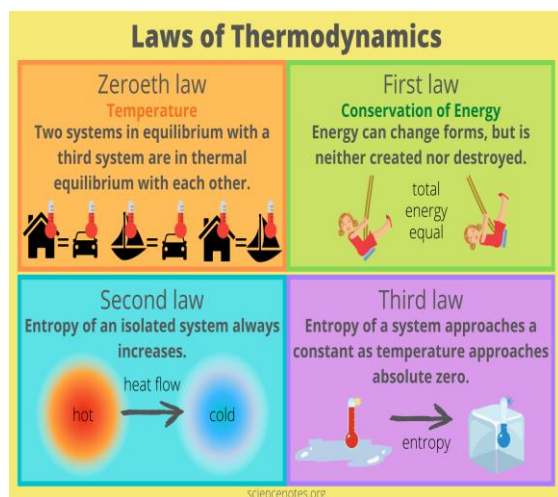
Three thermodynamics' laws

The most important laws of thermodynamics are:

The zeroth law of thermodynamics. When two systems are each in thermal equilibrium with a third system, the first two systems are in thermal equilibrium with each other. This property makes it meaningful to use thermometers as the “third system” and to define a temperature scale.

The first law of thermodynamics, or the law of conservation of energy. The change in a system's internal energy is equal to the difference between heat added to the system from its surroundings and work done by the system on its surroundings. In other words, energy can not be created or destroyed but merely converted from one form to another.

The second law of thermodynamics. Heat does not flow spontaneously from a colder region to a hotter region, or, equivalently, heat at a given temperature cannot be converted entirely into work. Consequently, the entropy of a closed system, or heat energy per unit temperature, increases over time toward some maximum value. Thus, all closed systems tend toward an equilibrium state in which entropy is at a maximum and no energy is available to do useful work.



The third law of thermodynamics. The entropy of a perfect crystal of an element in its most stable form tends to zero as the temperature approaches absolute zero. This allows an absolute scale for entropy to be established that, from a statistical point of view, determines the degree of randomness or disorder in a system.

Any physical system will spontaneously approach an equilibrium that can be described by specifying its properties, such as pressure, temperature, or chemical

composition. If external constraints are allowed to change, these properties generally change. The three laws of thermodynamics describe these changes and predict the equilibrium state of the system. The first law states that whenever energy is converted from one form to another, the total quantity of energy remains the same. The second law states that, in a closed system, the entropy of the system does not decrease. The third law states that, as a system approaches absolute zero, further extraction of energy becomes more and more difficult, eventually becoming theoretically impossible.

1.2* True (T) or False (F)?

1. ____ The zeroth law of thermodynamics explains the concept of thermal equilibrium.
2. ____ The first law of thermodynamics states that energy can be created or destroyed.
3. ____ Entropy in a closed system always decreases over time.
4. ____ The third law of thermodynamics states that entropy reaches zero at absolute zero temperature.
5. ____ A system can extract unlimited energy as it approaches absolute zero.
6. ____ Heat naturally flows from a colder body to a hotter body without external influence.
7. ____ The second law of thermodynamics limits the efficiency of heat engines.
8. ____ A thermometer works as a "third system" to measure temperature according to the zeroth law.
9. ____ All physical systems tend to reach equilibrium over time.
10. ____ The three main laws of thermodynamics describe energy conservation, entropy, and absolute zero conditions.

1.3* Comprehension Questions:

1. Why is the zeroth law of thermodynamics important for measuring temperature?

2. How does the second law of thermodynamics explain the concept of entropy?
3. What happens to a system's energy as it approaches absolute zero, according to the third law of thermodynamics?

1.4* Vocabulary and Terminology:

- Define the following terms: Zeroth law, thermal equilibrium, temperature scale, the first law of thermodynamics, conservation of energy, internal energy, the second law of thermodynamics, entropy, closed system, absolute zero.
- Translate the key terms into your native language and use them in sentences.

1.5* Write a brief summary of the fundamental laws of thermodynamics mentioned in the text.

1.6* Discussion Prompts:

1. If energy cannot be created or destroyed (first law), why do we still need fuel and other energy sources to power machines and devices?
2. The second law states that entropy always increases – does this mean that achieving perfect efficiency in any machine is fundamentally impossible? Why or why not?

1.7* Research and Presentation:

Prepare a presentation about energy, efficiency and the nature of thermodynamic systems conducting further research on them. Share your findings with the class.

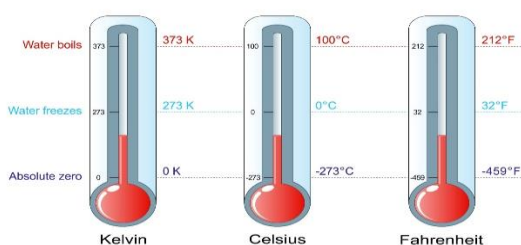
Text 2

2.1* Read and translate the following text. Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Temperature

The concept of temperature is fundamental to any discussion of thermodynamics, but its precise definition is not a simple matter. For example, a steel rod feels colder than a wooden rod at room temperature simply because steel is better at conducting heat away from the skin. It is therefore necessary to have an objective way of measuring temperature. In general, when two objects are brought into thermal contact, heat will flow between them until they come into equilibrium with each other. When the flow of heat stops, they are said to be at the same temperature. The zeroth law of thermodynamics formalizes this by asserting that if an object *A* is in simultaneous thermal equilibrium with two other objects *B* and *C*, then *B* and *C* will be in thermal equilibrium with each other if brought into thermal contact. Object *A* can then play the role of a thermometer through some change in its physical properties with temperature, such as its volume or its electrical resistance.

With the definition of equality of temperature in hand, it is possible to establish a temperature scale by assigning numerical values to certain easily reproducible fixed points. For example, in the Celsius ($^{\circ}\text{C}$) temperature scale, the freezing point of pure water is arbitrarily assigned a temperature of 0°C and the boiling point of water the value of 100°C (in both cases at 1 standard atmosphere). In the Fahrenheit ($^{\circ}\text{F}$) temperature scale, these same two points are assigned the values 32°F and 212°F ,



respectively. There are absolute temperature scales related to the second law of thermodynamics. The absolute scale related to the Celsius scale is called the Kelvin (K) scale, and that related to

the Fahrenheit scale is called the Rankine ($^{\circ}\text{R}$) scale. These scales are related by the equations $\text{K} = ^{\circ}\text{C} + 273.15$, $^{\circ}\text{R} = ^{\circ}\text{F} + 459.67$, and $^{\circ}\text{R} = 1.8 \text{ K}$. Zero in both the Kelvin and Rankine scales is at absolute zero.

2.2* Comprehension Questions:

1. How does the zeroth law of thermodynamics help define temperature?
2. Why does a steel rod feel colder than a wooden rod at the same temperature?
3. What is the difference between absolute temperature scales and traditional scales like Celsius and Fahrenheit?

2.3* Vocabulary and Terminology:

- Define the following terms: thermal equilibrium, heat flow, temperature scale, Kelvin scale, electrical resistance.
- Translate the key terms into your native language and use them in sentences.

2.4* Summarize the text about temperature in your own words in 5-6 sentences.

2.5* Discussion Prompts:

1. Since absolute zero is theoretically the lowest possible temperature, do you think it is possible to ever reach it? Why or why not?
2. Different materials feel hotter or colder to the touch even when they are at the same temperature. How does this affect the way we perceive temperature in everyday life?

2.6* Creative Writing:

A World Without Temperature: What If Heat Couldn't Flow?

Imagine a world where the concept of temperature does not exist – where heat never transfers from one object to another, and thermal equilibrium is never reached. How would this affect daily life, technology, and even human survival? Describe what such a world might look like and how people would adapt to this strange reality.

UNIT VI

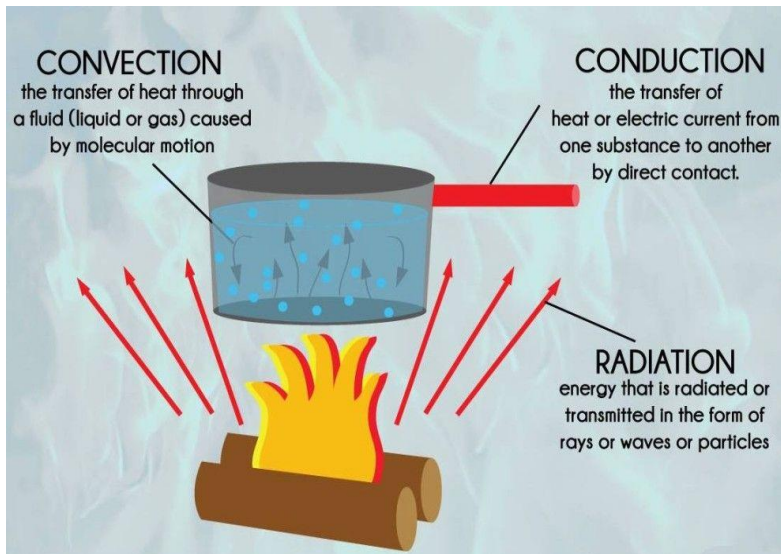
HEAT TRANSFER

TEXT

What is Heat Transfer?

1) Read and translate the text using the dictionary.

Heat transfer is the movement of thermal energy, in the form of heat, between physical systems with different temperatures using four distinct mechanisms – conduction, convection, and radiation. Heat transfer impacts almost every aspect of



modern life, from cooking food or cooling a laptop to generating electricity in a power plant. Every day, the heating of the Earth by solar radiation from the sun is a process of heat transfer, just as storms are caused by convection currents in the earth's atmosphere.

Heat transfer occurs as a natural phenomenon in any situation where there are temperature differences between two systems, as described in the second law of thermodynamics. Engineers also use heat transfer devices to move energy in the form of heat from one place to another, delivering heat where needed and removing it where it can cause problems. The safety, efficiency, and performance of products are driven by keeping the temperature of each part of a product within a desired temperature range.

Heat transfer is fundamentally about moving energy in the form of heat from one system to another. The discipline looks at the amount of energy that is stored or transferred in the form of heat and at the different ways that the energy is moved through the systems.

Here are some important terms used in heat transfer and their meaning.

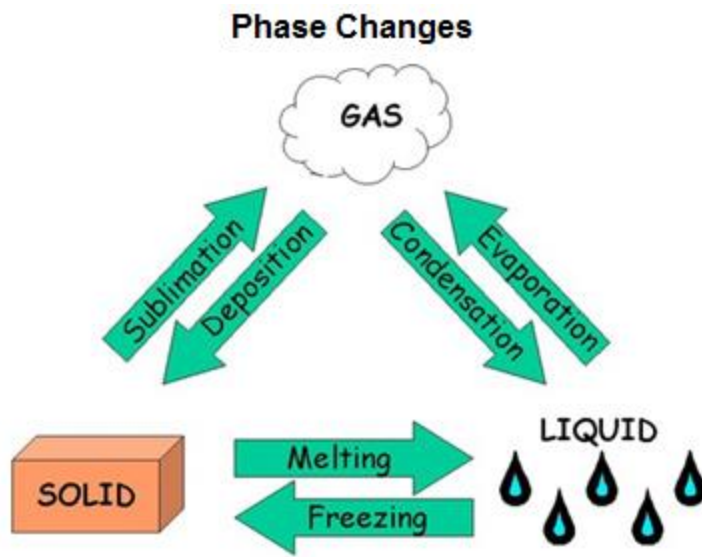
Convection currents refer to a fluid that sees a local temperature increase and corresponding density drop due to heating. The density drop creates a buoyancy force that causes the warmer fluid to rise until it cools. Then, as regions cool, the density decreases, and the fluid region is pulled down by negative buoyancy. These currents can easily be seen in a pot of boiling spaghetti, where the convective currents cause the pasta to twist and turn in the water.

The heat capacity of a system is the amount of heat needed to raise the temperature of the system by one degree. The higher the heat capacity, the more energy needed to increase its temperature. It is an important value in heat transfer because it reveals how materials respond to heat and how fast the object can heat up or cool down.

Heat flux measures the amount of energy transferring through a unit area. It is the total heat divided by the area of a surface where it is being measured. It is a critical value in heat transfer because it tells engineers the amount of energy traveling from one object to another or from an object to a fluid.

Heat generation is the creation of thermal energy through multiple processes, including chemical reactions, combustion, nuclear fusion, nuclear fission, thermoelectrics, electrical resistance, mechanical friction, or pressure changes in a fluid.

The heat transfer coefficient (h) of a surface measures the relationship between the heat flux between a surface and fluid touching the surface and the temperature difference between the surface and the fluid. The value can be calculated if you know the velocity and the thermal properties of the fluid. It is sometimes referred to as the film coefficient.



Just as heat transfer deals with the movement of heat from one system to another, mass transfer deals with the movement of mass. This is important in heat transfer because any mass moving between systems has an internal thermal energy that moves with the mass. Air moving over a heat sink is both mass transfer and heat transfer.

When matter transitions from one state to another, it undergoes a phase change. Strictly speaking, phase change is not heat transfer, but it is used with heat transfer to control temperatures in systems. The changes in molecular bonds inside the material changing phase absorb energy if going from solid to liquid (melting) or liquid to gas (boiling or vaporizing), and release energy if transitioning from gas to liquid (condensation) or liquid to solid (freezing). Engineers often use phase change to remove or add heat to a system.

The thermal conductivity (k) of a material is a measure of the ability of that material to conduct heat. The inverse of thermal conductivity is thermal resistivity.

b) Translate the italicized paragraph into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

2. Synonyms in Physics Vocabulary.

a) *Select five key terms from the text. For each term, create a list of 2 to 6 synonyms that capture the same or similar meanings within the context of physics. Below are examples to guide you:*

- Heat transfer – energy exchange, thermal transmission, heat flow, thermal movement.
- Conduction – direct transfer, thermal diffusion, heat flow, thermal conduction.
- Convection currents – fluid circulation, thermal flow, buoyant motion, heat-driven movement.
- Radiation – electromagnetic emission, thermal radiation, radiant energy, infrared emission.
- Phase change – state transition, phase shift, phase transition, material transformation.

b) Match the synonyms:

- | | |
|-------------------------|-----------------------------|
| 1. Heat transfer | a) Energy exchange |
| 2. Conduction | b) Direct transfer |
| 3. Convection | c) Fluid circulation |
| 4. Radiation | d) Electromagnetic emission |
| 5. Heat capacity | e) Thermal storage |
| 6. Heat flux | f) Energy flow |
| 7. Thermal conductivity | g) Heat transmission |
| 8. Phase change | h) State transition |
| 9. Heat generation | i) Thermal production |
| 10. Heat sink | j) Cooling system |

3. Using the dictionary transcribe and translate the key words and words combinations:

<i>Word</i>	<i>Transcription</i>	<i>Translation</i>
advection		
conduction		
convection		
radiation		
convection currents		
a buoyancy force		
heat flux		
velocity		
combustion		
chemical reactions		
nuclear fusion		
nuclear fission		
electrical resistance		
mechanical friction		
phase change		
thermal conductivity		
thermal resistivity		

4. Match the words with their definitions:

1) Heat transfer	a) The ability of a material to conduct heat.
2) Conduction	b) The total heat divided by the area of a surface where it is measured.
3) Convection currents	c) The movement of thermal energy between systems with different temperatures

4) Radiation	d) The circulation of fluid caused by temperature differences.
5) Heat capacity	e) The amount of energy needed to raise the temperature of a system by one degree.
6) Heat flux	f) The transfer of heat through direct contact between materials.
7) Heat generation	g) The process of producing thermal energy through combustion, friction, or other means.
8) Heat transfer coefficient	h) A measure of how efficiently heat is transferred between a surface and a fluid.
9) Phase change	i) The transition of matter from one state (solid, liquid, gas) to another.
10) Thermal conductivity	j) The transfer of heat through electromagnetic waves.

5. Give English equivalents to the meanings of the following words and word combinations.

теплопровідність	
конвекція	
радіаційне теплообмінювання	
конвекційні потоки	
теплоємність	
тепловий потік	
генерація тепла	
коефіцієнт теплопередачі	
фазовий перехід	
маса	

теплопровідність матеріалу	
тепловий опір	
поглинання енергії	
електромагнітне випромінювання	
тепловий розпад	
кипіння	
конденсація	
випаровування	
плавлення	
замерзання	

6. Read the statements below and decide whether they are true (T) or false (F) based on the text. If a statement is false, correct it.

1. ____ Heat transfer occurs only in solids.
2. ____ Convection involves the movement of fluids due to temperature differences.
3. ____ Radiation does not require a medium to transfer heat.
4. ____ Thermal conductivity measures how well a material resists heat transfer.
5. ____ The Sun heats the Earth mainly through conduction.
6. ____ Heat capacity is the amount of energy needed to raise an object's temperature by one degree.
7. ____ Conduction is the dominant heat transfer method in metals.
8. ____ Phase change, such as melting or freezing, does not involve heat transfer.
9. ____ A heat sink is used to remove excess heat from a system.
10. ____ Heat flux measures the amount of energy transferred per unit area.

7. Choose the correct answer:

1. Which of the following is NOT a method of heat transfer?

- A) Conduction
- B) Convection
- C) Radiation
- D) Reflection

2. What is the main heat transfer mechanism in metals?

- A) Convection
- B) Conduction
- C) Radiation
- D) Evaporation

3. Heat transfer by convection occurs in:

- A) Solids only
- B) Liquids and gases
- C) Metals only
- D) Vacuum

4. Which type of heat transfer does not require a medium?

- A) Conduction
- B) Convection
- C) Radiation
- D) All of the above

5. The amount of heat required to raise the temperature of an object by one degree is called:

- A) Heat capacity
- B) Thermal conductivity
- C) Heat flux
- D) Phase change

6. What happens to a fluid when it is heated?

- A) It becomes denser and sinks.
- B) It expands and rises.
- C) It contracts and remains still.
- D) It turns into a solid.

7. Which of the following materials is the best conductor of heat?

- A) Wood
- B) Glass
- C) Copper
- D) Plastic

8. What is the process called when a liquid turns into a gas?

- A) Condensation
- B) Freezing
- C) Evaporation
- D) Melting

9. Which of the following is the best way to translate the sentence?

The heat transfer coefficient (h) quantifies how efficiently heat is transferred between a surface and a fluid in contact with it, based on the heat flux and the temperature difference between them.

A) Коефіцієнт теплопередачі (h) визначає ефективність передачі тепла між поверхнею та рідиною, що з нею контактує, залежно від теплового потоку та різниці температур між ними.

B) Коефіцієнт теплопередачі – це ефективність передачі тепла між поверхнею та рідиною, що з нею контактує, залежно від теплового потоку та різниці температур між ними.

C) Коефіцієнт теплопередачі не визначає ефективність передачі тепла між поверхнею та рідиною, що з нею контактує, залежно від теплового потоку та різниці температур між ними.

D) Коефіцієнт теплопередачі (h) визначає ефективність передачі тепла між поверхнею та рідиною, тепловим потоком та різницею температур між ними.

10. The word combination *thermal decay* is translated into Ukrainian as

- A) теплова ізоляція
- B) теплова інерція
- C) теплове розширення
- D) тепловий розпад.

8. Translate the following sentences into Ukrainian:

1. Heat transfer is the process by which thermal energy moves from a region of higher temperature to a region of lower temperature through conduction, convection, or radiation.

2. The efficiency of heat transfer in a system depends on factors such as the thermal conductivity of materials, the presence of fluid motion, and the temperature gradient between interacting surfaces.

3. In conduction, heat is transferred through direct molecular interaction within a solid or between solids in thermal contact, without the movement of the material itself.

4. Convection involves the bulk movement of fluids, where warmer regions rise due to lower density while cooler regions sink, creating continuous circulation and enhancing heat transfer.

5. Radiation differs from conduction and convection as it allows heat transfer through electromagnetic waves, enabling energy transfer even in a vacuum, such as the heat received from the Sun.

9. Translate the following sentences into English:

1. Теплопередача – це процес переміщення теплової енергії від області з вищою температурою до області з нижчою температурою за допомогою

теплопровідності, конвекції або випромінювання.

2. Ефективність теплопередачі залежить від теплопровідності матеріалів, руху рідини та температурного градієнта між поверхнями, що взаємодіють.

3. При теплопровідності передача тепла відбувається через безпосередню взаємодію молекул у твердому тілі або між твердими тілами, що перебувають у контакті, без переміщення речовини.

4. Конвекція включає переміщення тепла разом із потоком рідини або газу, коли тепліші ділянки піднімаються через меншу густину, а холодніші опускаються, створюючи циркуляцію.

5. Випромінювання, на відміну від теплопровідності та конвекції, дозволяє передавати тепло за допомогою електромагнітних хвиль, що робить можливим перенесення енергії навіть у вакуумі, як у випадку з енергією Сонця.

10. Answer the questions to the text.

1. What are the four main mechanisms of heat transfer?
2. How does conduction transfer heat between objects?
3. Why does convection occur in fluids but not in solids?
4. What is the primary way the Sun transfers heat to the Earth?
5. How does the heat transfer coefficient (h) affect the efficiency of heat exchange?
6. What is the relationship between heat capacity and temperature change in a system?
7. Why is thermal conductivity an important property in materials used for heat transfer?
8. What happens during a phase change, and how does it relate to heat transfer?
9. What role does heat flux play in determining energy movement between systems?
10. How do engineers use heat transfer principles to improve product performance and safety?

SPEAKING

1. Guidelines for Discussion:

1. Define Key Concepts – Begin by explaining the main types of heat transfer (conduction, convection, and radiation) and provide real-life examples of each.

2. Use Technical Vocabulary – Incorporate terms like thermal conductivity, heat flux, phase change, and heat transfer coefficient to make your discussion more precise and academic.

3. Make Comparison – Discuss the differences and similarities between the heat transfer mechanisms and how they interact in real-world applications, such as in engineering or nature.

4. Provide Practical Examples – Relate the discussion to everyday experiences, such as how a metal spoon heats up in a hot drink (conduction) or how warm air rises in a room (convection).

5. Encourage Critical Thinking – Ask thought-provoking questions, like "Which heat transfer method is most efficient in insulating homes?" or "How does heat transfer impact climate change?", to engage deeper discussion.

2. Translate the following text into English:

a) Express the main idea of the text in one sentence.

b) Write a short summary of the text in English.

Теплопередача: основні механізми та їх значення

Теплопередача – це процес переміщення теплової енергії від одного об'єкта до іншого через різницю температур. Вона відіграє важливу роль у природі, техніці та повсякденному житті. Існує три основні механізми теплопередачі: теплопровідність, конвекція та випромінювання.

Теплопровідність відбувається, коли тепло передається через безпосередній контакт між частинками. Найкраще тепло проводять метали, тому, наприклад,

ручка металевої ложки, залишеної в гарячому супі, швидко нагрівається. Проте такі матеріали, як дерево або пластик, мають низьку теплопровідність і діють як ізолятори.

Конвекція характерна для рідин і газів. Коли вода у каструлі нагрівається, гарячі шари піднімаються вгору, а холодні опускаються, утворюючи конвекційні потоки. Аналогічний процес відбувається і в атмосфері Землі, створюючи вітри, океанічні течії та навіть погоду.

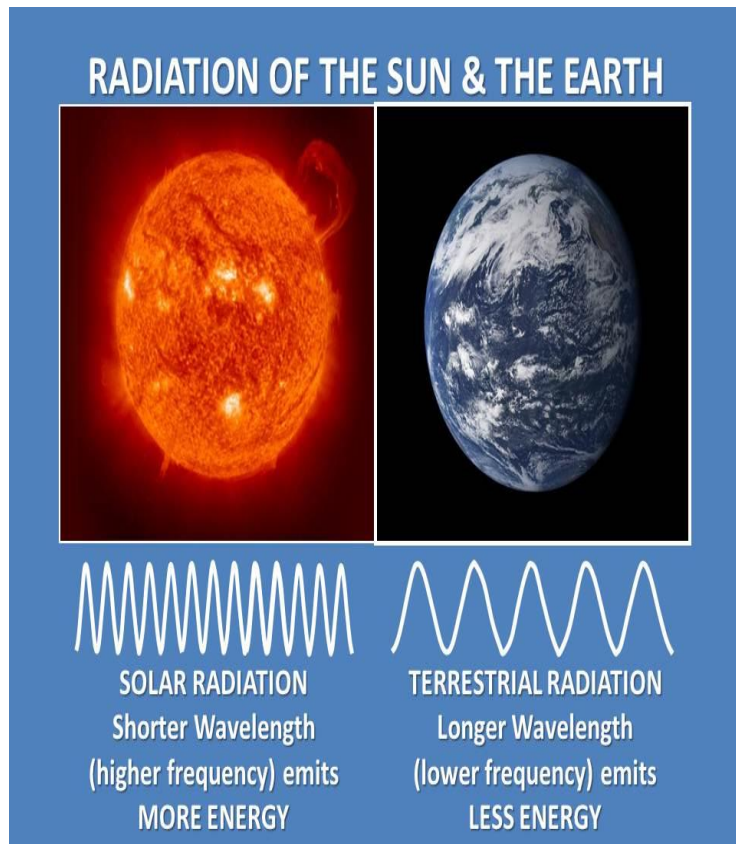
Випромінювання передає тепло через електромагнітні хвилі, без потреби у фізичному контакті. Найяскравіший приклад – сонячне світло, яке нагріває Землю. Інші джерела випромінювання включають інфрачервоні обігрівачі, багаття або навіть тепло людського тіла.

Практичне застосування теплопередачі. Розуміння теплопередачі є надзвичайно важливим у багатьох сферах. У будівництві використовують теплоізоляційні матеріали, щоб зменшити втрати тепла в зимовий період. В інженерії це знання допомагає створювати ефективні охолоджувальні системи для електроніки та двигунів. У медицині термографія дозволяє виявляти запальні процеси в організмі, використовуючи принцип теплового випромінювання.

Таким чином, теплопередача є фундаментальним фізичним процесом, що впливає на різні аспекти нашого життя – від кліматичних змін до технологій, які ми використовуємо щодня.

EXTENDED READING*

1.1* Read and translate the following text. Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:



Radiation is the transfer of heat by means of electromagnetic waves. If something radiates, it protrudes or spreads outward from a point of origin. The transfer of heat by radiation involves the carrying of energy from an origin to the space surrounding it. The energy is carried by electromagnetic waves and does not involve the movement or the interaction of matter. Thermal radiation can occur through matter or through a region of space devoid of matter (a vacuum). In fact, the

heat received on Earth from the sun is the result of electromagnetic waves traveling through the space between the Earth and the Sun.

All objects radiate energy in the form of electromagnetic waves. The hotter the object, the more it radiates. The sun obviously radiates more energy than a hot mug of coffee. The temperature also affects the wavelength and frequency of the radiated waves. Objects at typical room temperature radiate energy as infrared waves. Infrared energy is invisible to the human eye, but an infrared camera is capable of detecting it. Thermal photographs or videos of the radiation surrounding a person or animal or a hot mug of coffee or the Earth illustrate this method of heat transfer. The camera detects the radiation emitted by objects and represents it by means of a color photograph. The hotter colors represent areas of objects are emitting thermal radiation at a more intense rate.

Heat affects substances in different ways. First, it changes the temperature of an object. If heat is transferred from an object to the surroundings, then the object can cool down and the surroundings can warm up. When heat is transferred to an object by its

surroundings, then the object can warm up and the surroundings can cool down. Heat, once absorbed as energy, contributes to the overall internal energy of the object. One form of this internal energy is kinetic energy; the particles begin to move faster, resulting in greater kinetic energy. This more vigorous motion of particles is reflected by a temperature increase. The reverse logic applies as well. Energy, once released as heat, results in a decrease in the overall internal energy of the object. The second thing that heat does is that it contributes to changes in state of a substance. The addition of heat to a sample of matter can cause solids to turn to liquids and liquids to turn to gases. Similarly, the removal of heat from a sample of matter can cause gases to turn to liquids and liquids to turn to solids. Each of these transitions between states occur at specific temperatures - commonly referred to as melting point temperature, freezing point temperature, boiling point temperature and condensation point temperature.

1.2* Comprehension Questions:

1. What is radiation, and how does it transfer heat?
2. Why does radiation not require matter to transfer heat?
3. How does the Sun transfer heat to the Earth?
4. How does the temperature of an object affect the amount of radiation it emits?
5. What type of electromagnetic waves do objects at room temperature emit?
6. How can infrared radiation be detected if it is invisible to the human eye?
7. What happens when heat is transferred from an object to its surroundings?
8. How does heat absorption affect the internal energy and motion of particles in an object?
9. What are the four main phase changes mentioned in the text?
10. Why do substances change state at specific temperatures?

1.3* Vocabulary and Terminology:

a) Define the following terms: melting point, boiling point, kinetic energy, infrared waves, thermal radiation.

b) Translate the key terms into your native language and use them in sentences.

c) Below are 10 sentences with missing words. Use the given terms to complete each sentence correctly.

1. Radiation
2. Electromagnetic waves
3. Thermal radiation
4. Infrared waves
5. Kinetic energy
6. Internal energy
7. Heat transfer
8. Phase change
9. Melting point
10. Boiling point

d) Fill in the blanks:

1. The Sun transfers heat to the Earth through _____, allowing us to feel warmth even in space.

2. _____ can travel through a vacuum, making it possible for heat from the Sun to reach us.

3. The process of _____ allows objects to emit heat in the form of invisible waves.

4. _____ cameras can detect heat emissions from living beings, even in complete darkness.

5. When an object is heated, its particles move faster, increasing their _____.

6. The total energy stored inside a substance, including its thermal and molecular motion, is called _____.
7. _____ occurs when heat moves from a hotter object to a cooler one.
8. When ice turns into water, it undergoes a _____ from solid to liquid.
9. The _____ of a substance is the temperature at which it changes from solid to liquid.
10. Water reaches its _____ at 100°C , turning into steam.

e) Answer the questions:

1. What is radiation in terms of heat transfer?
 - A) The transfer of heat through direct contact.
 - B) The transfer of heat by movement of fluids.
 - C) The transfer of heat by electromagnetic waves.
 - D) The transfer of heat through solids only.
2. Why can radiation occur in a vacuum?
 - A) Because it does not require matter to transfer heat.
 - B) Because particles move faster in a vacuum.
 - C) Because air molecules carry the heat.
 - D) Because heat energy is absorbed by space.
3. Which of the following objects radiates the most energy?
 - A) A cup of cold water.
 - B) A warm mug of coffee.
 - C) The Sun.
 - D) A piece of ice.
4. What type of electromagnetic waves do objects at room temperature mostly emit?
 - A) Ultraviolet waves.
 - B) Infrared waves.

- C) X-rays.
- D) Radio waves.

5. How can infrared radiation be detected?

- A) By using a regular digital camera.
- B) By measuring the temperature with a thermometer.
- C) By using an infrared camera.
- D) By observing the object's color with the naked eye.

6. What happens to an object when it absorbs heat from its surroundings?

- A) It cools down.
- B) It remains at the same temperature.
- C) It warms up as its internal energy increases.
- D) It turns into a solid.

7. Which statement is true about changes in state due to heat transfer?

- A) Removing heat from a gas turns it into a solid immediately.
- B) Adding heat to a liquid can turn it into a gas.
- C) A substance does not need heat to change state.
- D) All substances change state at the same temperature.

8. What happens to the kinetic energy of particles when an object is heated?

- A) It decreases as the object cools.
- B) It remains constant.
- C) It increases as the particles move faster.
- D) It causes the object to freeze.

9. Which of the following temperatures is NOT related to a phase change?

- A) Boiling point.
- B) Freezing point.
- C) Room temperature.
- D) Melting point.

10. How does a thermal camera display temperature differences?

- A) By using a thermometer inside the camera.
- B) By detecting electromagnetic waves and converting them into colors.
- C) By measuring the object's density.
- D) By sensing visible light emitted by the object.

1.4* Based on what you have learned, write a **short summary (3-5 sentences)** explaining how **radiation and heat transfer** work. Use at least three of the terms from the list above in your summary.

1.5* Discussion Prompts:

1. How do conduction, convection, and radiation affect daily activities like cooking, heating homes, or using electronic devices?
2. How can we use knowledge of heat transfer to develop sustainable energy solutions?
3. Technological applications of heat transfer:
 - How do engineers apply heat transfer principles in designing engines, spacecraft, or cooling systems?
 - Why is infrared technology important in medical, military, and industrial applications?
 - What future innovations could improve heat management in electronics, buildings, or renewable energy systems?

1.6* Research and Presentation:

Step 1: Choose a topic

Select one of the following topics or propose your own:

- The three mechanisms of heat transfer: conduction, convection, and radiation.
- The role of thermal radiation in climate change and the greenhouse effect.

- How heat transfer is used in engineering (e.g., cooling systems, insulation, energy efficiency).
- Infrared technology and its applications in medicine, security, and industry.
- The impact of heat transfer on everyday life (e.g., cooking, home heating, weather patterns).

Step 2: Conduct research

- Find reliable sources (scientific articles, textbooks, online research, experiments).
- Take notes on key concepts, real-world examples, and interesting facts.
- Use visuals (diagrams, images, graphs) to support your findings.

Step 3: Prepare Your Presentation

Introduction: Briefly introduce your topic and its importance.

Main content: Explain key concepts, provide examples, and use visuals.

Conclusion: Summarize main points and discuss possible applications or future developments.

Be ready to answer questions from your audience.

UNIT VII

ELECTRICITY & MAGNETISM

TEXT

Electromagnetism: Basic Principles

1. a) Read and translate the text using the dictionary.

Electromagnetism is an interaction that occurs between particles with electric charge via electromagnetic fields. The word *electromagnetism* comes from a combination of the Greek words *elektron*, meaning "amber" and *magnetis lithos*, meaning "Magnesian stone," a magnetic iron ore. The ancient Greeks were familiar with electricity and magnetism but considered them two separate phenomena.

Basic Principles of Electricity

Electricity is the phenomenon associated with either stationary or moving electric charges. The source of the electric charge could be an elementary particle, an electron (which has a negative charge), a proton (which has a positive charge), an ion, or any larger body that has an imbalance of positive and negative charge. Positive and negative charges attract each other (e.g., protons are attracted to electrons), while like charges repel each other (e.g., protons repel other protons and electrons repel other electrons). Familiar examples of electricity include lightning, electrical current from an outlet or battery, and static electricity. Common SI units of electricity include the ampere (A) for current, coulomb (C) for electric charge, volt (V) for potential difference, ohm (Ω) for resistance, and watt (W) for power. A stationary point charge has an electric field, but if the charge is set in motion, it also generates a magnetic field.

Basic Principles of Magnetism

Magnetism is defined as the physical phenomenon produced by moving electric charges. Also, a magnetic field can induce charged particles to move, producing an

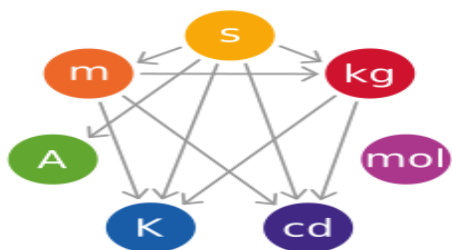
electric current. An electromagnetic wave (such as light) has an electric and magnetic component. The two wave components travel in the same direction but are oriented at a right angle (90 degrees) to one another.

Like electricity, magnetism produces attraction and repulsion between objects. While electricity is based on positive and negative charges, no known magnetic monopoles exist. Any magnetic particle or object has a "north" and "south" pole, with the directions based on the orientation of the Earth's magnetic field. Like magnet poles repel each other (e.g., north repels north), while opposite poles attract one another (north and south attract).

Familiar examples of magnetism include a compass needle's reaction to Earth's magnetic field, the attraction and repulsion of bar magnets, and the field surrounding electromagnets. Yet, every moving electric charge has a magnetic field, so the orbiting electrons of atoms produce a magnetic field, there is a magnetic field associated with power lines, and hard discs and speakers rely on magnetic fields to function. Key SI units of magnetism include the tesla (T) for magnetic flux density, weber (Wb) for magnetic flux, ampere per meter (A/m) for magnetic field strength, and henry (H) for inductance.

The electromagnetic force is one of the four fundamental forces of nature. It is the dominant force in the interactions of atoms and molecules. Electromagnetism can be thought of as a combination of electrostatics and magnetism, which are distinct but closely intertwined phenomena. Electromagnetic forces occur between any two charged particles. Electric forces cause an attraction between particles with opposite charges and repulsion between particles with the same charge, while magnetism is an interaction that occurs between charged particles in relative motion. These two forces are described in terms of electromagnetic fields. Macroscopic charged objects are described in terms of Coulomb's law for electricity and Ampère's force law for magnetism; the Lorentz force describes microscopic charged particles.

The electromagnetic force is responsible for many of the chemical and physical phenomena observed in daily life. The electrostatic attraction between atomic nuclei and their electrons holds atoms together. Electric forces also allow different atoms to combine into molecules, including the macromolecules such as proteins that form the basis of life. Meanwhile, magnetic interactions between the spin and angular momentum magnetic moments of electrons also play a role in chemical reactivity; such relationships are studied in spin chemistry. Electromagnetism also plays several crucial roles in modern technology: electrical energy production, transformation and distribution; light, heat, and sound production and detection; fiber optic and wireless communication; sensors; computation; electrolysis; electroplating; and mechanical motors and actuators.

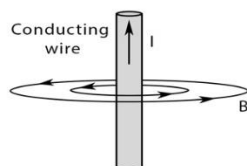


Notes:

- 1. SI units** (The International System of Units) is a system of measurement based on 7 base units: the metre (length), kilogram (mass), second (time), ampere (electric current), kelvin (temperature), mole (quantity), and candela (brightness).

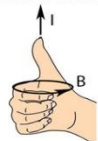
2. Coulomb's law of magnetism states that, if two magnetic poles of strengths m_1 and m_2 are held apart at a distance r then the force of attraction or repulsion between the two poles is

Ampere's Law



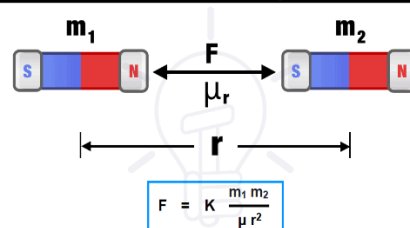
Integral form: $\oint \vec{B} \cdot d\vec{l} = \mu_0 I$
 Differential form: $\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}$
 I : Electric current
 B : Magnetic field
 μ_0 : Permeability of free space
 J : Current density

Right hand thumb rule



Thumb points in the direction of the electric current and fingers curl around the current indicating the direction of the magnetic field

Coulomb's Laws of Magnetic Force

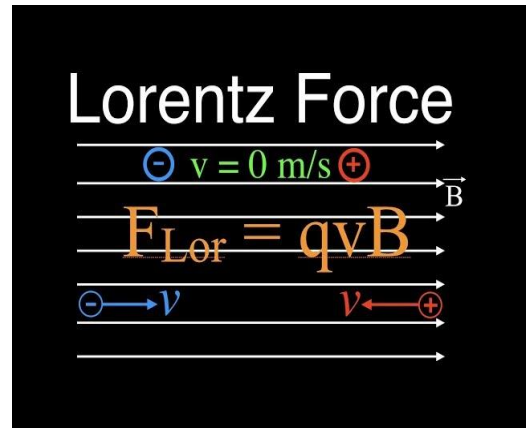


directly proportional to the product of their pole strengths and inversely proportional to the distance square between them.

3. Ampère's force law for magnetism states that the force of attraction or repulsion between two current-carrying

wires is proportional to their lengths and the current flowing through them. A current-carrying conductor placed in a magnetic field will experience a force that is perpendicular to both fields.

4. The Lorentz force law is the combination of electric and magnetic force on a point charge due to electromagnetic fields. It is a physical effect that occurs in the vicinity of electrically neutral, current-carrying conductors causing moving electrical charges to experience a magnetic force.



b) Translate the italicized paragraph into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

2. Synonyms in Physics Vocabulary.

a) These synonym groups will help you improve understanding of the interconnected terms in electromagnetism. Remember them.

1. Electricity → electric power, electrical energy, electric charge flow, current.

2. Magnetism → magnetic force, magnetic attraction, magnetic effect, magnetic interaction.

3. Attraction → pull, drawing force, magnetic pull, electrostatic attraction.

4. Repulsion → push, repelling force, electrostatic repulsion, magnetic repelling.

5. Electric charge → charge, electrical load, electron imbalance.

6. Magnetic field → magnetic force field, magnetic influence, magnetic area.

7. Electromagnetic force → electromagnetic interaction, electromagnetic effect.

8. Potential difference → voltage, electrical potential, electric tension.

- 9. Resistance** → electrical resistance, impedance, opposition to current.
- 10. Conductor** → electrical conductor, current carrier, conductive material.
- 11. Insulator** → non-conductor, dielectric material, electrical barrier.
- 12. Electromagnetic wave** → electromagnetic radiation, light wave, energy wave.
- 13. Power** → electrical power, energy output, work rate.
- 14. Induction** → electromagnetic induction, magnetic influence, electrical generation.

b) Below are several key terms related to electromagnetism. Find synonyms or closely related words based on the text. Some words may not have direct synonyms but can be explained using other terms from the text or from the list above.

Electricity, magnetism, attraction, repulsion, electric charge, magnetic field, electromagnetic force, potential difference, induction, resistance.

c) Choose the correct synonym from the word bank to complete each sentence.

Word Bank: current, potential difference, attraction, repulsion, resistance.

1. The movement of electric _____ through a circuit generates power.
2. The force that pulls opposite charges together is called _____.
3. _____ occurs when two like charges push away from each other.
4. A battery creates a _____ to drive electric current.
5. Some materials have high _____, making it harder for electricity to flow.

3. Using the dictionary transcribe and translate the key words and words combinations:

Word	Transcription	Translation
electric charge		
electromagnetic fields		

imbalance		
electrical current		
resistance		
electromagnetic wave		
repulsion		
repel		
inductance		
electrostatic attraction		
atomic nuclei		
electrolysis		
electroplating		
macromolecule		
hold atoms together		
insulator		
impedance		

4. Match the words with their definitions:

1. Attract	a) A tool with a needle that always points north, used for showing direction.
2. Compass	b) To pull something closer.
3. Generator	c) A power plant that produces electricity from moving water that turns turbines connected to generators.
4. Hydroelectric plant	d) A machine that turns motion into electricity.
5. Lines of force	e) The end of a magnet where lines of force flow out.
6. Nuclear power	f) Invisible lines of magnetic force that flow through and around a magnet, forming a magnetic field.

7. Permanent magnet	g) A factory that makes electricity by splitting or joining.
8. Repel	h) To push something away.
9. Temporary magnet	i) A material that is always magnetic.
10. North pole	j) A material that is magnetic only while in the magnetic field produced by an electric current or a permanent magnet.

5. Give English equivalents to the meanings of the following words and word combinations.

Електричний заряд	
Напруга	
Струм	
Опір	
Потужність	
Магнітне поле	
Електричне поле	
Провідник	
Ізолятор	
Електромагнітна хвиля	
Магнітний потік	
Індуктивність	
Ампер	
Вольт	
Ом	
Електростатичне притягання	
Електростатичне відштовхування	

6. Read the statements below and decide whether they are true (T) or false (F) based on the text. If a statement is false, correct it.

1. ____ The term "electromagnetism" comes from Latin words meaning "electric stone."
2. ____ The ancient Greeks believed that electricity and magnetism were the same phenomenon.
3. ____ Electricity involves both stationary and moving electric charges.
4. ____ Like charges attract each other, while opposite charges repel each other.
5. ____ A moving electric charge creates both an electric field and a magnetic field.
6. ____ Magnetism is caused by moving electric charges.
7. ____ Magnetic poles exist separately, just like electric charges.
8. ____ Electromagnetic force is one of the four fundamental forces of nature.
9. ____ Atoms and molecules interact mainly due to gravitational force.
10. ____ Electromagnetism is widely used in modern technology, including electrical energy production and communication.

7. Choose the correct answer:

1. What does electromagnetism describe?
 - A) The interaction between gravitational and electric forces.
 - B) The interaction between electric charges and magnetic fields.
 - C) The movement of heat through conductors.
 - D) The effect of sound waves on charged particles.
2. The word "electromagnetism" comes from Greek words meaning:
 - A) "Electric force and magnetic energy".
 - B) "Lightning and iron".
 - C) "Amber and Magnesian stone".

D) "Electricity and conduction".

3. What is a fundamental characteristic of electric charge?

- A) Only electrons have charge.
- B) Like charges attract, and opposite charges repel.
- C) Opposite charges attract, and like charges repel.
- D) Charges do not interact with each other.

4. What happens when an electric charge moves?

- A) It generates a gravitational field.
- B) It creates both an electric and a magnetic field.
- C) It loses its charge.
- D) It stops interacting with other charges.

5. Which of the following is NOT a unit used in electromagnetism?

- A) Ampere (A)
- B) Volt (V)
- C) Newton (N)
- D) Tesla (T).

6. How do magnetic poles behave?

- A) A north pole can exist without a south pole.
- B) Like poles repel, and opposite poles attract.
- C) Magnetic poles do not interact with each other.
- D) They create electric charges.

7. What is the role of the electromagnetic force in nature?

- A) It is weaker than the gravitational force.
- B) It has no impact on atomic or molecular interactions.
- C) It is responsible for holding atoms and molecules together.
- D) It only works in artificial environments.

8. Which law describes the force between two electric charges?

- A) Ohm's Law.

- B) Coulomb's Law.
- C) Faraday's Law.
- D) Newton's Third Law

9. What happens when a magnetic field interacts with a moving electric charge?

- A) It produces a gravitational effect.
- B) It induces an electric current.
- C) It neutralizes the charge.
- D) It stops the charge from moving.

10. Which of the following is an example of electromagnetism in daily life?

- A) A stretched rubber band.
- B) A compass needle pointing north.
- C) Water boiling at 100°C.
- D) The force of friction between two surfaces.

11. Which of the following is the best way to translate the sentence?

Key SI units of magnetism include the tesla (T) for magnetic flux density, weber (Wb) for magnetic flux, ampere per meter (A/m) for magnetic field strength, and henry (H) for inductance.

A) Ключові одиниці SI для магнетизму включають тесла (Т) для магнітної індукції, вебер (Wb) для магнітного потоку, ампер на метр (A/ m) для напруженості магнітного поля та генрі (Н) для індуктивності.

В) Основними одиницями Міжнародної системи одиниць (SI) є тесла (Т) для магнітної індукції, вебер (Wb) для магнітного потоку, ампер на метр (A/m) для напруженості магнітного поля та генрі (Н) для індуктивності.

С) Ключові одиниці SI для магнетизму включають вольт (W) для магнітної індукції, вебер (Wb) для магнітного потоку, ампер на метр (A/ m) для напруженості магнітного поля та генрі (Н) для індуктивності.

D) Ключові одиниці SI для електрики та магнетизму включають тесла (T) для магнітної індукції, вебер (Wb) для магнітного потоку, ампер на метр (A/ m) для напруженості магнітного поля та генрі (H) для індуктивності.

8. Translate the following sentences into Ukrainian:

1. An electric charge can originate from an elementary particle, such as an electron with a negative charge, a proton with a positive charge, an ion, or any larger object that has an uneven distribution of positive and negative charges.

2. Electromagnetism is essential in modern technology, contributing to the generation, conversion, and distribution of electrical energy and involving in the production and detection of light, heat, and sound, as well as in fiber optic and wireless communication, sensors, computing, electrolysis, electroplating, and the operation of electric motors and actuators.

3. Electromagnetism can be viewed as a fusion of electrostatics and magnetism, two separate yet deeply interconnected phenomena.

4. Electric forces enable atoms to bond and form molecules, including macromolecules like proteins, which serve as the foundation of life.

5. A motionless point charge creates an electric field, but when it starts moving, it also produces a magnetic field.

9. Translate the following sentences into English:

1. Електромагнітна сила є однією з чотирьох фундаментальних сил природи.

2. Рухомий електричний заряд створює як електричне, так і магнітне поле.

3. Магнітне поле може змусити заряджені частинки рухатися, створюючи електричний струм.

4. Протилежні електричні заряди притягуються, а однакові заряди відштовхуються.

5. Електромагнітні хвилі мають електричну та магнітну складові, які рухаються під кутом 90 градусів одна до одної.

10. Answer the questions to the text.

1. What is electromagnetism, and how does it relate to electric charge?
2. What is the origin of the word "electromagnetism"?
3. How did the ancient Greeks perceive electricity and magnetism?
4. What are the main differences between electric and magnetic forces?
5. What happens when an electric charge is set in motion?
6. Which SI units are used to measure different aspects of magnetism?
7. How does the electromagnetic force influence atomic and molecular interactions?
8. What are some real-world applications of electromagnetism in modern technology?
9. How do magnetic poles behave compared to electric charges?
10. What laws describe the interactions of electric and magnetic fields?

11. Write a short summary of the text “Electromagnetism: Basic Principles” (See the scheme in the Information File – ex. 11 p. 16) and be ready to present it.

SPEAKING

1. Guidelines for Discussion:

1. Use Key Terms.

Try to include important vocabulary from the text, such as electric charge, magnetic field, induction, resistance, Coulomb’s law, etc.

2. Give Examples.

Support your points with real-life examples, like how electromagnets are used in MRI machines, speakers, or electric motors.

3. Connect to Everyday Life.

Discuss how electromagnetism affects daily activities, such as using a smartphone, charging a battery, or seeing lightning.

4. Compare and Contrast.

Highlight the differences and similarities between electricity and magnetism, or static and moving charges.

5. Ask Questions.

Engage others by asking follow-up questions, such as How would technology change if electromagnetism didn't exist?

6. Relate to History.

Mention key scientists like Faraday, Maxwell, or Tesla, and how their discoveries shaped our understanding of electromagnetism.

7. Stay Open-Minded.

Respect different viewpoints and try to build on others' ideas during the discussion.

2. Translate the following text into English:

- a) Express the main idea of the text in one sentence
- b) Write a short summary of the text in English.

Електромагнетизм: основи та значення

Електромагнетизм – це фундаментальна взаємодія між електричними і магнітними полями, що виникає внаслідок руху електричних зарядів. Він є однією з чотирьох основних сил природи поряд із гравітацією, сильними та слабкими ядерними взаємодіями.

Основи електромагнетизму закладені в рівняннях Максвелла, які описують взаємозв'язок електричних і магнітних полів, а також їхню поведінку в просторі та часі. Електричне поле створюється нерухожими зарядженими частинками, тоді як магнітне поле виникає при русі заряджених частинок або змінах електричного поля.

Закон Фарадея про електромагнітну індукцію пояснює, як зміна магнітного потоку може створювати електричний струм у провіднику. Це явище широко використовується в генераторах електроенергії та трансформаторах. Закон Ампера, у свою чергу, описує, як електричний струм створює магнітне поле навколо провідника.

Електромагнітна взаємодія відіграє ключову роль у сучасній технології. Вона використовується в електродвигунах, радіозв'язку, медичних приладах (наприклад, МРТ-сканерах), комп'ютерах та багатьох інших сферах. Окрім цього, електромагнітні хвилі, до яких належать радіохвилі, мікрохвилі, інфрачервоне випромінювання, видиме світло, ультрафіолет, рентгенівські та гамма-промені, є основою для багатьох технологій зв'язку та діагностики.

Таким чином, електромагнетизм є невід'ємною частиною природи і технологічного прогресу. Його вивчення допомагає розширювати наукові горизонти та вдосконалювати сучасні технології.

EXTENDED READING *

1.1* Learn something new with these facts of electricity!

Read and translate the following texts. Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms.

1. Ever wondered how fast does electricity travel? The answer is the speed of light!

It has been proven that electricity travels at the same speed as light, which totals an astonishing 670,616,629 miles per hour. To break this down further, 670,616,629 miles per hour equals 300 million meters per second!

So, how does electricity travel so quickly? Well, it is all down to a combination of electrons and an electric current. A flow of electricity is made from many minuscule particles, otherwise known as electrons. When static, the electrons actually move incredibly slowly. However, whenever you use an electrical device, it will be equipped with a wire, which is what enables the electrons to travel from your power supply to your device. The flow is technically known as an electric current, which will only begin its journey when you turn on your device.

2. Lightning is caused by the discharge of electricity in the atmosphere.

Lightning is, in fact, caused by one huge electric current. While the clouds may seem to be peacefully moving across the sky, they are actually deceptively active. With ever-changing weather conditions, water and ice are forced up into the atmosphere by warm air currents and then forced back down by gravity. During their travels, the pair become compressed in the clouds, circulating not only around but also inside.

Over time, an electric charge starts to build up inside the clouds – similar to when you rub a balloon against a surface to create static electricity. Inside the clouds, there are now positive electric charges building up at the top and negative resting along the bottom. These then try their hardest to reach each other in an attempt to neutralize.

On a normal day, this isn't a problem; however, on a stormy day, the turbulent winds cause the electric charges to separate. The negative charges start moving towards the ground, known to scientists as a 'stepped leader.' In the meantime, an 'upward leader' forms on the earth below, pushing positive charges up into the air. When these meet, they create a giant electric current, which shoots up into the cloud – this is known as lightning!

3. Electricity was first discovered in 600 BC.

There are many reports that state different dates regarding the discovery of electricity. However, according to Universe Today, electricity dates back as far as 600 BC with the Ancient Greeks. The Greeks concluded that by rubbing fur against amber made from fossilized tree resin, they could create their own form of static electricity.

In addition to the Greek discovery, it is also thought that the Romans may have used electricity to create batteries. Back in the 1930s, archaeologists tracked down a set of posts that were designed with copper sheets hidden inside. Experts believe that the Romans used these pots as batteries to power lights.

4. Electric cars actually date back as far as 1832.

While most see electric vehicles as a relatively new invention, they actually date back as far as the 1800s. Between 1828 and 1835, Hungarian and American innovators were the first to experiment with small-scale electric cars. Budding inventor, Robert Anderson, developed the first crude electric vehicle in 1832; however, it wasn't until the 1870s that the car became 'driveable' and able to transport passengers from A to B.

More than 60 years after its first invention, the electric vehicle started to grow in popularity. Models were finally easy to drive and no longer gave off a pungent smell of pollutants. They were particularly sought-after amongst women, who wanted a stylish vehicle to travel around the city. By the next century, it is thought that electric cars accounted for up to one-third of all vehicles on the roads! For more information on the history behind the electric car, take a look at [Energy.Gov](#) for a detailed timeline.

5. Electric eels can produce up to a 600-volt shock.

While this fact may seem a little peculiar, it was too interesting not to include in our article! Despite the name, electric eels are actually a type of fish, but this doesn't change the fact that they can be incredibly dangerous. Each eel is born with around 6,000 specialized cells known as electrocytes; these are capable of producing an enormous electrical charge of up to 600 volts. Luckily, the eels only release this charge when they are either hunting or spot a predator.

6. 54% of all electricity is wasted.

We're always encouraged to try our very hardest to make the most out of the energy we use, but why? Based on a recent report by The Association for Decentralized Energy, a vast 54% of energy is wasted every single year in the UK, which amounts to a shocking £9.5 billion. When this is broken down further, per household alone, this could

be as much as £354, which is more than half the average electricity bill of those living in the UK.

While this is most definitely a surprising statistic, there are many super easy ways to begin to save energy in the home. From unplugging gadgets when they are no longer in use to washing clothes at a lower temperature, you can start making savings in no time.

7. It's the water in the body that causes an electric shock.

Having worked as electricians in Milton Keynes for several years, you would be surprised how many emergency calls we receive from customers who have given themselves an electric shock. While we're all cautious to ensure that we stay safe around electrics, did you know that the cause of a shock is actually the water inside your body? As humans, our bodies are made up of up to 60% water, which makes us fantastic conductors of electricity. High-powered electricity is always on the lookout for the path which offers the least resistance and if we come into contact with it, this means that it goes straight to the water flowing through the body, resulting in an electric shock. In return, the muscles begin to tighten, and the lungs become narrower, causing an instant and dangerous reaction.

8. Electricity plays a role in your heartbeat.

Every function and movement within the body is triggered through signals, including your heart. Each time that your heart is given the go-ahead to beat, blood is pumped around the body. This signal is passed through the body anywhere from 40-something to over 100 times a minute. This particular function is, in fact, caused by your body's own electricity.

The heart's electrical system is made up of three key structures; these are scientifically known as the S-A Node, A-V Node and His-Purkinje System. The S-A Node, also known as the heart's natural pacemaker, is a collection of cells which is in the upper-right of your heart. These cells are responsible for sending the signals to tell your heart to beat. The signals then travel to the A-V Node, which is a form of 'bridge'

for the electricity to pass through. Lastly, once this reaches the His-Purkinje System, your heart will beat.

9. LED lightbulbs use 80% less electricity

When using a conventional lightbulb, only around 10% of the electricity used to power the bulb actually goes on light – a huge 90% is wasted through heat. This is just one of the many reasons why more and more homeowners are opting to switch to LED alternatives, not to mention how much better they are for the environment!

Trading in your regular old lightbulbs for LEDs comes alongside an array of benefits. Not only do they use more than five times less energy, but they also last 25 times longer and cost six times less.

10. Some electrics should be tested every 12-24 months.

If you're a business or commercial premises owner, you need to ensure that electrical devices are regularly PAT tested to guarantee their safety. During a PAT test, electrical appliances are assessed through visual inspections and electronic tests. They'll then be marked as either pass or fail. There are no set rules regarding the time period for checking as it differs based on the industry that you're in. For example, equipment in schools should be tested every 12 months, whereas those in an office can be every 48 months.

As specialists in PAT testing in Milton Keynes, Heath Electrical Services are always more than happy to visit you on-site to check that all appliances are in good working order. All electricians are NICEIC registered, which means that all testing will be completed to the highest standard.

1.2* Comprehension Questions:

1. At what speed does electricity travel, and why does it move so quickly?
2. How does lightning form, and what role do electric charges play in this process?
3. When and how was electricity first discovered, according to historical reports?

4. Who developed the first crude electric vehicle, and when did electric cars become more popular?
5. How do electric eels generate an electric shock, and for what purposes do they use it?
6. What percentage of electricity is wasted annually in the UK, and how can people reduce energy waste?
7. Why does the human body conduct electricity so well, and how does this lead to electric shocks?
8. How does electricity play a role in the human heartbeat, and what structures control this function?
9. Why are LED lightbulbs considered more energy-efficient than traditional bulbs?
10. What is PAT testing, and why is it important for electrical safety in businesses?

1.3* Vocabulary and Terminology:

- Define the following terms: electricity, electric current, electrons, lightning, static electricity, electric charge, electromagnetic waves, induction, electric vehicle, electric eel, energy waste, conductor, electric shock, heartbeat electrical system, LED lightbulb, PAT testing.
- Translate the key terms into your native language and use them in sentences.

1.4* Write a brief summary of key discoveries and applications of electricity in our everyday life.

1.5* Discussion Prompts:

- 1. Electricity is essential in both nature and technology.** In what ways does electricity impact daily life, and how would the world be different without it?
- 2. Energy efficiency is a growing concern.** What are some practical ways individuals and businesses can reduce electricity waste, and why is this important?

3. The history of electricity dates back centuries. Which historical discovery or invention related to electricity do you find most interesting, and why?

1.6* Research and Presentation:

Choose one fact of the fascinating facts about electricity mentioned in the text and conduct further research on it. Prepare a presentation about its role in nature and technology to share your findings with the class.

UNIT VIII

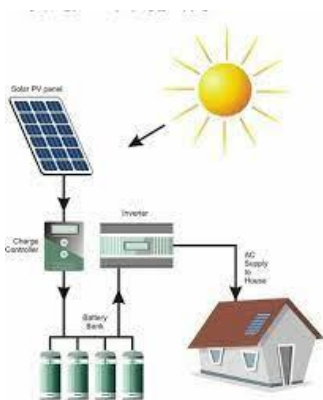
RENEWABLE ENERGY SOURCES

TEXT

Sustainable Power of the Future

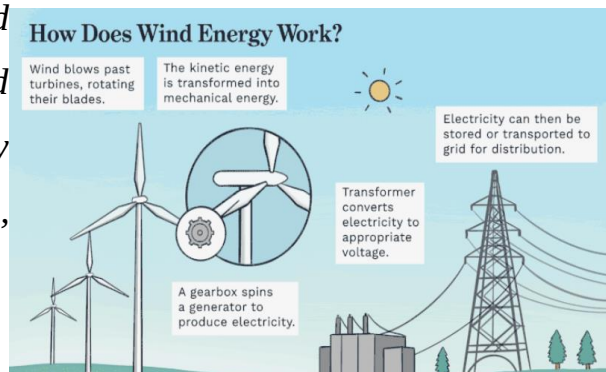
1. a) Read and translate the text using the dictionary:

Renewable energy sources are key to creating a sustainable and environmentally friendly future. Unlike fossil fuels, which are limited and harmful to our planet, renewable energy comes from natural sources that are plentiful and cause minimal pollution. Some of the main types of renewable energy include solar, wind, hydroelectric, geothermal, and biomass energy.



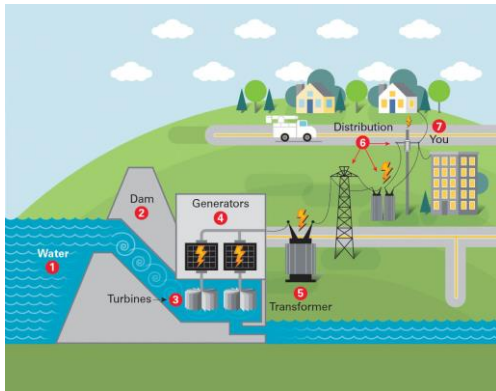
Solar Energy is harvested from the sun using solar panels or mirrors that concentrate sunlight. These technologies convert sunlight into electricity. Over recent years, solar technology has improved a lot, making solar panels more efficient and affordable. Solar energy is used everywhere, from home rooftops to vast solar farms. Innovations in solar batteries have made it easier to store energy for later use, ensuring that people have power even when the sun isn't shining. Solar energy helps reduce carbon emissions and gives people the ability to produce their own electricity.

Wind Energy is created by using wind turbines to convert the wind's kinetic energy into electrical power. Advances in wind technology have produced more efficient and powerful turbines that can generate electricity even with low wind speeds. Offshore wind farms,



which are built in the ocean where winds are stronger and more consistent, are becoming increasingly popular. Wind energy is now a major contributor to the world's energy supply and provides a clean, renewable source of power. The growth of the wind industry has also created many jobs in manufacturing, installation, and maintenance.

Hydroelectric Energy comes from harnessing the power of moving water,

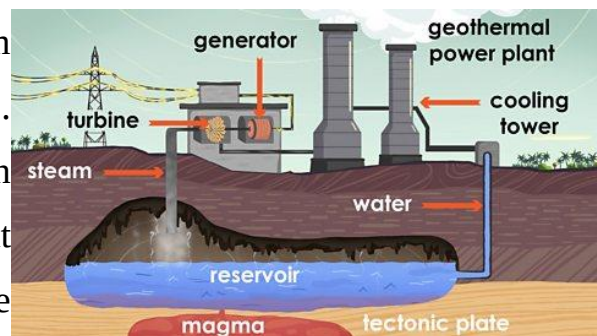


usually from rivers or dams. This form of energy has been used for decades and is one of the most reliable and efficient sources of renewable power. Recently, new technologies have been developed for small-scale hydroelectric systems, making it possible to generate electricity in remote and rural areas. Hydroelectric power not only provides clean energy but also helps

with water management and flood control.

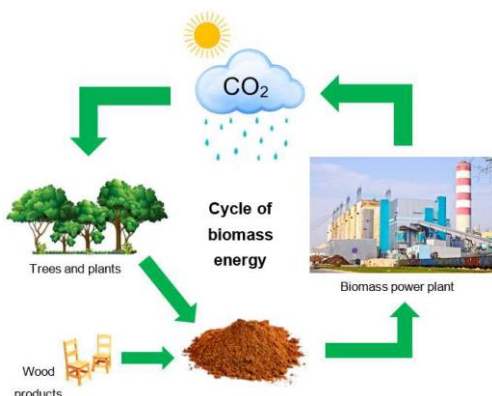
Geothermal Energy uses heat from within the Earth to produce electricity and provide heating. This energy is accessed by

drilling wells to tap into hot water and steam reservoirs beneath the Earth's surface. Geothermal energy is very reliable and can provide a steady supply of power. Recent



advancements have made it possible to use geothermal energy in areas with lower temperatures, expanding its potential. Geothermal plants have a small environmental impact and produce very little pollution.

Biomass Energy is generated from organic materials like plant and animal waste, wood, and agricultural residues. These materials can be converted into biofuels, biogas, and bioenergy through various processes. Biomass energy provides a way to utilize



waste materials and reduce greenhouse gas emissions. Recent advancements include more efficient conversion processes and the use of algae as a source of biofuel. Biomass energy is a versatile and renewable energy option that can be integrated into existing energy systems.

In summary, renewable energy sources are essential for tackling climate change, ensuring energy security, and promoting environmental sustainability. The advancements in solar, wind, hydroelectric, geothermal, and biomass energy technologies have made them more efficient, affordable, and accessible. By harnessing these natural sources, we can move towards a cleaner and more sustainable energy future, reducing our dependence on fossil fuels and mitigating the effects of climate change.

b) Translate the italicized paragraphs into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

2. Synonym Groups for Physics Vocabulary:

Select 5 key terms from the text. For each term, create a list of 2 to 6 synonyms that capture the same or similar meanings within the context of physics. Below are examples to learn and to guide you.

1. **Photovoltaic (PV) cells** - Solar cells - Solar panels - PV modules - Photovoltaic modules

2. **Kinetic Energy** - Motion energy - Dynamic energy - Movement energy - Mechanical energy

3. **Electricity Generation** - Power production - Energy generation - Electrical output - Power generation

4. **Renewable Energy** - Green energy - Sustainable energy - Eco-friendly energy
- Clean energy

5. **Greenhouse Gas Emissions** - Carbon emissions - GHG emissions - Carbon dioxide emissions - Climate emissions

6. **Sustainable** — Eco-friendly — Green — Renewable - Environmentally friendly

7. **Advancements** — Progress — Developments — Innovations — Improvements

8. **Efficient** — Effective — Productive — Proficient — Competent

9. **Reduction** — Decrease — Diminution — Lessening — Minimization

10. **Mitigating** — Alleviating — Reducing — Lessening - Easing

3. Using the dictionary transcribe and translate the key words:

Word	Transcription	Translation
renewable		
sustainable		
fuel		
efficient		
advancements		
turbines		
supply		
maintenance		
hydroelectric		
electricity		
reservoirs		

advancements		
environmental		
algae		
versatile		

4. Match the words with their definition:

1. Photovoltaic (PV) Cells	a) The release of gases, such as carbon dioxide and methane, into the atmosphere that contribute to the greenhouse effect and global warming.
2. Kinetic Energy	b) Electricity generated by harnessing the energy of flowing water, typically from rivers or dams, to spin turbines connected to generators.
3. Electricity Generation	c) A technology that uses mirrors or lenses to concentrate a large area of sunlight onto a small area to generate thermal energy, which can then be used to produce electricity.
4. Renewable Energy	d) Devices that convert sunlight directly into electricity through the photovoltaic effect. They are the fundamental components of solar panels.
5. Greenhouse Gas Emissions	e) The heat derived from the Earth's internal geothermal processes. This energy can be harnessed for electricity generation and direct heating applications.
6. Concentrated Solar Power	f) Fuels produced from organic materials, such as plant and animal biomass, through processes like fermentation and anaerobic digestion. Common examples include

	ethanol and biodiesel.
7. Offshore Wind Farms	g) The energy possessed by an object due to its motion. In the context of wind energy, it is the energy harnessed from moving air.
8. Geothermal Energy	h) Energy obtained from natural sources that are replenished on a human timescale, such as sunlight, wind, rain, tides, waves, and geothermal heat.
9. Hydroelectric Power	i) Wind turbines located in bodies of water, typically on the continental shelf, that harness wind energy to generate electricity. They benefit from stronger and more consistent winds compared to onshore wind farms.
10. Biofuel	j) The process of producing electrical power from various energy sources, such as fossil fuels, nuclear, or renewable sources like solar, wind, and hydro.

5. Give English equivalents to the meanings of the following words and word combinations:

екологічно чисте майбутнє	
гідроелектрична, геотермальна енергія та енергія біомаси	
перетворювати сонячне світло в електрику	
більш ефективний і доступний	
кінетична енергія вітру	
потужні турбіни	

генерувати електроенергію	
відновлюване джерело енергії	
виготовлення, монтаж і обслуговування	
малі гідроелектросистеми	
водне господарство	
контроль за повеннями	
під поверхнею Землі	
останні досягнення	
геотермальні установки	
вплив на навколишнє середовище	
процеси перетворення	
біопаливо	
універсальний	
природні джерела	
залежність від викопного палива	
наслідки зміни клімату	
існуючі енергетичні системи	

6. Find synonyms to the words and word combinations:

1. Important -
2. Create -
3. Energy -
4. Technology -
5. Clean -

- 6. Reduce -
- 7. Improve -
- 8. Reliable -
- 9. Protect -
- 10. Cost -

7. Choose the correct answer:

1. What are solar panels primarily used for?

- A) Storing wind energy
- B) Converting sunlight into electricity
- C) Producing geothermal heat
- D) Generating biomass energy

2. Which renewable energy source uses wind turbines to generate electricity?

- A) Solar energy
- B) Geothermal energy
- C) Wind energy
- D) Biomass energy

3. What is one of the main benefits of hydroelectric power?

- A) It uses fossil fuels
- B) It produces high carbon emissions
- C) It provides clean energy and helps with water management
- D) It relies on geothermal heat

4. Geothermal energy is derived from:

- A) Solar radiation
- B) The Earth's internal heat
- C) Wind currents
- D) Ocean tides

5. Biomass energy is generated from:

- A) Fossil fuels
- B) Organic materials such as plant and animal waste
- C) Nuclear reactions
- D) Geothermal reservoirs

6. Which of the following is NOT a renewable energy source mentioned in the text?

- A) Wind energy
- B) Solar energy
- C) Nuclear energy
- D) Geothermal energy

7. What advancements have made solar panels more efficient and affordable?

- A) Fossil fuel technology
- B) Innovations in solar technology
- C) Increased use of nuclear power
- D) Traditional energy sources

8. How do wind turbines contribute to the energy supply?

- A) By storing solar energy
- B) By converting kinetic energy from wind into electrical power
- C) By generating heat from the Earth's core
- D) By decomposing organic materials

9. Which is the best way to translate the following sentence:

Renewable energy sources help reduce greenhouse gas emissions.

- A) Відновлювані джерела енергії допомагають зменшити викиди парникових газів.
- B) Відновлювані джерела енергії підвищують викиди парникових газів.
- C) Відновлювані джерела енергії збільшують викиди парникових газів.
- D) Відновлювані джерела енергії не впливають на викиди парникових газів.

10. Which is the best way to translate the following sentence:

Wind turbines convert kinetic energy from wind into electrical power.

- A) Вітрові турбіни перетворюють кінетичну енергію вітру на електричну енергію.
- B) Вітрові турбіни перетворюють кінетичну енергію вітру на теплову енергію.
- C) Вітрові турбіни перетворюють кінетичну енергію вітру на механічну енергію.
- D) Вітрові турбіни перетворюють кінетичну енергію вітру на хімічну енергію.

8. Translate the following sentences into Ukrainian:

1. The development of wind turbines has significantly improved our ability to harness wind energy efficiently.
2. Solar panels are becoming more widespread due to their decreasing costs and increasing efficiency.
3. Geothermal energy offers a reliable and sustainable way to generate electricity from the Earth's internal heat.
4. Biomass energy provides a renewable solution by converting organic waste materials into usable fuel.
5. Advancements in hydroelectric power have made it possible to generate clean energy from small-scale water sources.

9. Translate the following sentences into English:

1. Гідроелектростанції використовують енергію проточної води для виробництва чистої та відновлюваної електроенергії.
2. Останні досягнення в галузі біомаси зробили процес перетворення органічних відходів на паливо більш ефективним.
3. Офшорні вітрові ферми мають потенціал генерувати значні кількості електроенергії завдяки сильним і стабільним вітрам над океаном.
4. Геотермальні електростанції забезпечують сталий джерело енергії, використовуючи внутрішнє тепло Землі.
5. Зменшення витрат і підвищення ефективності сонячних панелей сприяє їх широкому впровадженню по всьому світу.

10. Answer the questions to the text?

1. What are the primary benefits of renewable energy sources compared to fossil fuels?
2. How do photovoltaic (PV) cells convert sunlight into electricity?
3. What technological advancements have improved the efficiency of solar panels in recent years?
4. Why are offshore wind farms becoming more popular compared to onshore wind farms?
5. How does hydroelectric power contribute to both clean energy production and water management?
6. What makes geothermal energy a reliable and sustainable source of electricity?
7. How is biomass energy generated from organic materials?
8. In what ways have advancements in biomass technology improved the efficiency of converting waste into fuel?
9. What role do solar batteries play in enhancing the reliability of solar energy?
10. How do wind turbines convert the kinetic energy of wind into electrical power?

11. Write a short summary of the text (See the scheme in the Information File – ex. 11 p. 16) and be ready to present it.

S P E A K I N G

1. Guidelines for Discussion:

1. Explore the Environmental Benefits of Renewable Energy:

Discuss how renewable energy sources, such as solar and wind power, contribute to reducing greenhouse gas emissions and mitigating climate change. What specific environmental advantages do these technologies offer compared to fossil fuels?

2. Evaluate the Economic Impact of Renewable Energy:

Analyze the economic benefits of investing in renewable energy technologies. How do advancements in solar, wind, and other renewable sources create job opportunities and stimulate economic growth? Consider both short-term and long-term economic impacts.

3. Investigate the Technological Advancements in Renewable Energy:

Examine recent technological innovations in renewable energy, such as improvements in solar panel efficiency or the development of offshore wind farms. How have these advancements enhanced the reliability and accessibility of renewable energy?

4. Discuss the Challenges and Solutions in Implementing Renewable Energy:

Identify the major challenges associated with the widespread adoption of renewable energy sources. What are some potential solutions to overcome these obstacles, such as advancements in energy storage or grid integration?

5. Consider the Future of Renewable Energy:

Reflect on the future prospects of renewable energy technologies. What emerging trends and innovations could shape the future of renewable energy? How can governments, industries, and individuals contribute to the transition towards a more sustainable energy landscape?

2. Translate the following text into English:

a) Express the main idea of the text in one sentence;

b) Write and be ready to present a short summary of the text in English.

Використання штучного інтелекту для оптимізації відновлюваних джерел енергії

З розвитком технологій штучний інтелект (ШІ) знаходить все більше застосувань у різних галузях. Відновлювані джерела енергії не є винятком. Використання ШІ для оптимізації виробництва, розподілу та споживання

відновлюваної енергії стає ключовим елементом у створенні стійкої енергетичної системи.

Одним із найважливіших застосувань ІІІ у сфері відновлюваної енергетики є аналіз великих масивів даних та прогнозування. Штучний інтелект здатен обробляти дані з різних джерел, таких як метеорологічні станції, датчики на вітрових турбінах та сонячних панелях, та створювати точні прогнози щодо виробництва енергії.

ІІІ може також допомогти оптимізувати роботу енергетичних мереж. Використовуючи алгоритми машинного навчання, енергетичні компанії можуть автоматично регулювати розподіл енергії, враховуючи змінні умови попиту та пропозиції. Це допомагає зменшити втрати енергії, підвищити ефективність роботи мережі та забезпечити стабільне постачання електроенергії.

Штучний інтелект також може сприяти підвищенню ефективності використання відновлюваних джерел енергії. Наприклад, алгоритми ІІІ можуть аналізувати дані про роботу сонячних панелей та вітрових турбін, виявляти потенційні несправності та передбачати необхідність технічного обслуговування. Це дозволяє знизити експлуатаційні витрати та збільшити строк служби обладнання.

Штучний інтелект відкриває нові можливості для розвитку відновлюваної енергетики та створення стійкої енергетичної системи. Використання ІІІ для аналізу даних, оптимізації мереж, підвищення ефективності використання ресурсів та моделювання дозволяє значно покращити роботу відновлюваних джерел енергії. Це сприяє зниженню викидів парникових газів, підвищенню енергетичної незалежності та забезпеченню сталого розвитку для майбутніх поколінь.

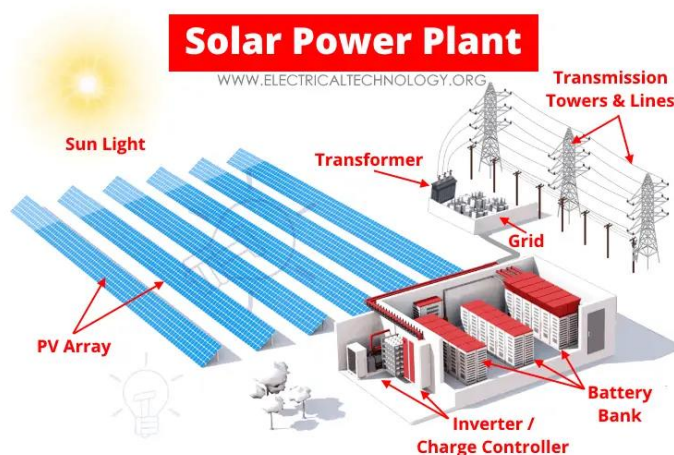
EXTENDED READING *

1.1* Read and translate the following text. Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Text 1

Harnessing the Sun: The Role and Benefits of Solar Farms

Solar farms, also known as solar power plants or photovoltaic (PV) power stations, are large-scale installations designed to convert sunlight into electricity. These farms consist of vast arrays of solar panels that capture solar energy and transform it into usable electrical power. Solar farms play a critical role in the transition towards renewable energy and the reduction of greenhouse gas emissions.



At the heart of a solar farm are photovoltaic (PV) cells, which are made from semiconductor materials such as silicon. When sunlight strikes these cells, it excites the electrons within the material, creating an electric current. This direct current (DC) is then converted into alternating current (AC)

by inverters, making it suitable for use in homes, businesses, and the electrical grid.

There are two main types of solar farms: utility-scale solar farms and community solar farms.

1. Utility-Scale Solar Farms: These are large installations that can generate enough electricity to power thousands of homes and businesses. They are typically built in areas with high solar insolation and ample space, such as deserts or open fields. The electricity produced is fed directly into the grid, contributing to the overall energy supply.

2. Community Solar Farms: These smaller-scale solar farms allow multiple households or businesses to share the benefits of solar power. Members of the community can subscribe to a portion of the solar farm's output, reducing their energy bills and supporting renewable energy without needing to install panels on their own properties.

Solar farms offer numerous advantages:

1. Environmental Impact: Solar farms generate clean, renewable energy, significantly reducing carbon emissions and reliance on fossil fuels. This helps mitigate climate change and reduce air pollution, leading to improved public health.

2. Energy Independence: By harnessing the power of the sun, solar farms contribute to energy independence. They reduce the need for imported energy sources and enhance the stability and security of the energy supply.

3. Economic Growth: The construction and operation of solar farms create jobs in manufacturing, installation, maintenance, and management. This stimulates local economies and provides new employment opportunities.

4. Scalability: Solar farms can be scaled up or down based on energy needs and available space. This flexibility makes them an attractive option for both large utility companies and small communities.

5. Land Use: Solar farms can be installed on otherwise unused or underutilized land, such as brownfields, abandoned industrial sites, or agricultural land with low productivity. This optimizes land use and brings new value to these areas.

Despite their benefits, solar farms face challenges such as land availability, initial investment costs, and intermittency due to weather conditions. However, ongoing advancements in solar technology, energy storage solutions, and grid integration are addressing these issues. Innovations such as bifacial panels, floating solar farms, and solar tracking systems are enhancing the efficiency and viability of solar farms.

In conclusion, solar farms are a vital component of the renewable energy landscape. They offer a sustainable and environmentally friendly solution to meet the

world's growing energy demands. As technology continues to advance, solar farms will play an increasingly important role in shaping a clean and sustainable energy future.

1.2* Comprehension Questions:

What are the main components of a solar farm and how do they work to generate electricity?

1. What are the main components of a solar farm and how do they work to generate electricity?
2. Explain the difference between utility-scale solar farms and community solar farms.
3. What are the environmental benefits of solar farms?
4. How do solar farms contribute to energy independence?
5. What challenges do solar farms face, and what advancements are being made to address them?

1.3* Vocabulary and Terminology:

a) Define the following terms	b) Match the terms to their definitions
1. Photovoltaic (PV) cells	a) Devices that convert sunlight directly into electricity.
2. Inverters	b) Systems that transform direct current (DC) from solar panels into alternating current (AC).
3. Utility-scale solar farms	c) Large installations that generate enough electricity to power thousands of homes.
4. Community solar farms	d) Smaller-scale solar farms that allow multiple households to share solar power.
5. Bifacial panels	e) Panels that capture sunlight from both sides for increased efficiency.

1.4* Write a brief summary of the text in your own words in 5-6 sentences.

1.5* Discussion Prompts:

1. Discuss the potential economic impacts of solar farms on local communities. How do they create jobs and stimulate economic growth?
2. Explore the technological advancements that have improved the efficiency of solar farms. What innovations are enhancing their viability and performance?
3. Reflect on the role of solar farms in achieving energy independence. How do they reduce reliance on imported energy sources?
4. Debate the challenges and potential solutions in the development and implementation of solar farms. What obstacles need to be overcome for their widespread adoption?
5. Analyze the environmental benefits of solar farms. How do they contribute to reducing greenhouse gas emissions and mitigating climate change?

1.6* Research and Presentation:

Explore the role of interdisciplinary collaboration in the development of solar farms. Identify how engineers, environmental scientists, and policymakers work together to advance this technology. Present your findings and discuss the importance of teamwork in achieving sustainable energy solutions.

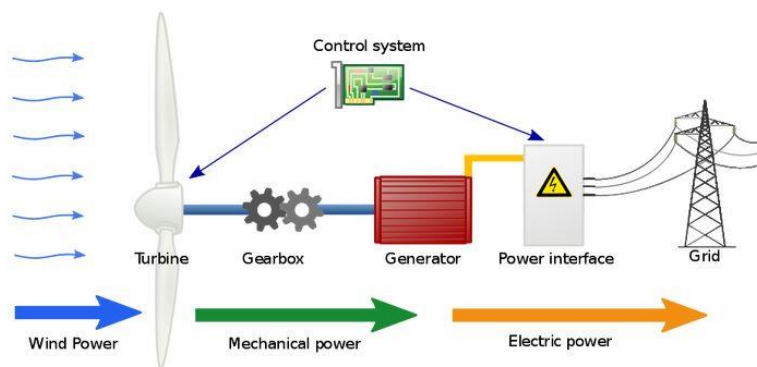
Text 2

2.1* Read and translate the following texts Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Harnessing the Wind's Kinetic Energy

The wind's kinetic energy, often referred to as wind energy, is the energy possessed by moving air. This form of energy has been utilized for centuries, from sailing ships and windmills to modern wind turbines that generate electricity. Wind energy is a clean, renewable, and abundant source of power that plays a crucial role in the global transition to sustainable energy systems.

Kinetic energy is the energy that an object possesses due to its motion. In the context of wind energy, the kinetic energy of the wind is derived from the movement of air molecules. The amount of kinetic energy in the wind depends on the speed and mass of the moving air. Faster and denser winds carry more energy, making them ideal for power generation.



Wind turbines are the primary technology used to convert the wind's kinetic energy into electrical power. A wind turbine consists of several key components, including blades, a rotor, a nacelle, and a tower. Here's a step-by-step breakdown

of how wind turbines work:

1. Capture: As the wind blows, it moves the turbine blades, causing them to rotate. The blades are designed to capture as much wind energy as possible by efficiently converting the wind's kinetic energy into mechanical energy.

2. Rotation: The rotating blades turn the rotor, which is connected to a shaft inside the nacelle. The nacelle houses the generator and other mechanical components.

3. Generation: The shaft turns the generator, which converts the mechanical energy into electrical energy. This process involves the interaction of magnetic fields and conductors within the generator.

4. Transmission: The generated electricity is transmitted through cables to a substation, where it is transformed into a higher voltage for distribution through the power grid.

5. Distribution: The electricity is then distributed to homes, businesses, and industries, providing a clean and renewable source of power.



Wind energy offers numerous advantages that make it an attractive option for power generation:

1. Renewable and Sustainable: Wind is a natural, inexhaustible resource that can be harnessed without depleting the Earth's resources.

2. Low Environmental Impact: Wind energy produces no greenhouse gas emissions or air pollutants, making it an environmentally friendly alternative to fossil fuels.

3. Economic Benefits: The wind industry creates jobs in manufacturing, installation, and maintenance. It also provides income for landowners who lease their land for wind farms.

4. Energy Independence: Wind energy reduces reliance on imported fossil fuels, enhancing energy security and stability.

5. Scalability: Wind farms can be built onshore and offshore, allowing for flexibility in site selection and scalability based on energy needs.

Despite its benefits, wind energy faces challenges such as intermittency, visual and noise impacts, and land use conflicts. However, ongoing research and technological advancements are addressing these issues. Innovations in turbine design, energy storage solutions, and grid integration are improving the efficiency and reliability of wind energy systems.

In conclusion, the wind's kinetic energy is a powerful and sustainable resource that has the potential to significantly contribute to global energy needs. By harnessing this

natural force, we can reduce our carbon footprint, promote energy independence, and pave the way for a cleaner and more sustainable future.

2.2* Comprehension Questions:

1. What is kinetic energy and how is it related to wind energy?
2. Explain the process of how wind turbines convert the wind's kinetic energy into electrical power.
3. List the advantages of wind energy mentioned in the text.
4. What are some challenges faced by wind energy, and how are they being addressed?
5. How does wind energy contribute to energy independence?

2.3* Vocabulary and Terminology:

Define the following terms	Match the terms to their definitions
1. Kinetic energy	a) The energy an object possesses due to its motion.
2. Wind turbines	b) Devices that convert the wind's kinetic energy into electrical power.
3. Rotor	c) The component of a wind turbine that houses the generator and other mechanical parts.
4. Nacelle	d) The rotating part of a wind turbine that captures wind energy.
5. Alternating current (AC)	e) The type of electrical current used in homes and businesses, converted from direct current (DC).

2.4* Summarize the text in your own words in 5-6 sentences.

2.5* Discussion Prompts:

1. Discuss the environmental benefits of wind energy compared to traditional fossil fuels.
2. Explore the economic impact of the wind energy industry on local communities. How does it create jobs and stimulate economic growth?
3. Reflect on the technological advancements in wind turbine design. How have these innovations improved the efficiency and reliability of wind energy?
4. Debate the potential solutions to the challenges faced by wind energy, such as intermittency and land use conflicts.
5. Analyze the role of wind energy in reducing carbon emissions and combating climate change.

2.6* Research and Presentation:

Select a real-world case study of a successful wind farm project. Analyze the impact of this project on the local community, environment, and energy supply. Present your findings with supporting data and evidence.

UNIT IX

NANOTECHNOLOGY

TEXT

Exploring the World of Nanotechnology

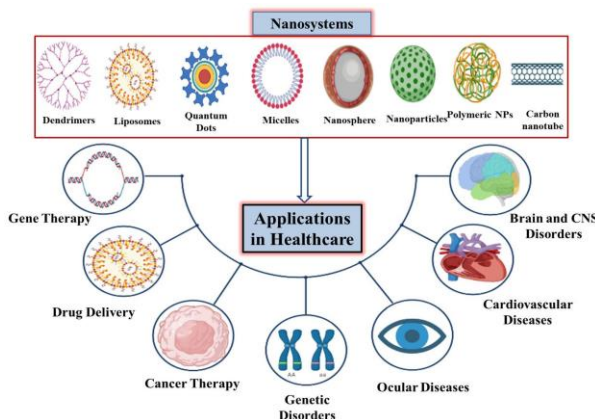
1. a) Read and translate the text using the dictionary:

Nanotechnology, often referred to as "nano," is a rapidly advancing field of science and engineering that involves the manipulation and control of matter on an atomic and molecular scale. This cutting-edge technology operates at the nanometer scale, with one nanometer being one-billionth of a meter, or about 100,000 times smaller than the diameter of a human hair. The unique properties of materials at this scale open up a myriad of possibilities for innovation across various industries.

At the core of nanotechnology is the ability to precisely control and manipulate individual atoms and molecules. This level of control allows scientists and engineers to create materials with specific properties and functions that are not possible with bulk materials. Nanotechnology leverages principles from physics, chemistry, biology, and engineering to design and fabricate nanoscale devices and structures.

Applications of Nanotechnology

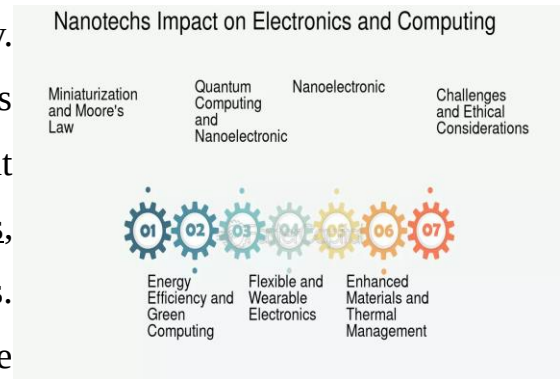
1. Medicine and Healthcare: Nanotechnology has the potential to revolutionize



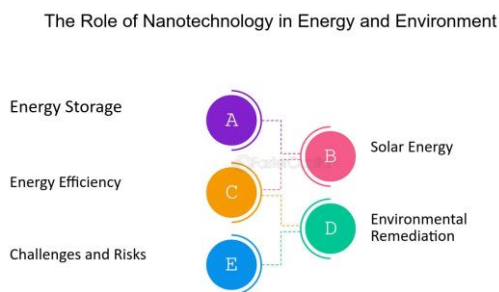
medicine by enabling targeted drug delivery systems, early disease detection, and advanced diagnostic tools. For instance, nanoparticles can be engineered to deliver drugs directly to cancer cells, minimizing side effects and

improving treatment efficacy. Additionally, nanoscale sensors can detect biomarkers of diseases at very early stages, allowing for prompt intervention.

2. Electronics and Computing: The miniaturization of electronic components through nanotechnology has led to significant advancements in computing power and efficiency. Nanoscale transistors, which are the building blocks of modern processors, have enabled the development of faster and more powerful computers, smartphones, and other electronic devices. Nanotechnology also plays a crucial role in the development of flexible and wearable electronics.



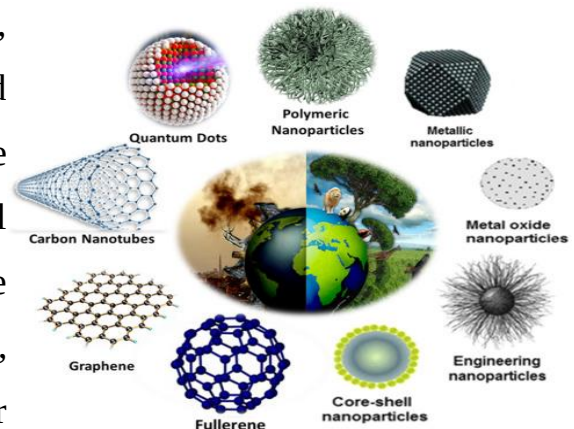
3. Energy and Environment: Nanotechnology offers innovative solutions for



energy generation, storage, and conservation. For example, nanomaterials are used to create more efficient solar cells, batteries, and fuel cells. Additionally, nanotechnology can help address environmental challenges by enabling the

development of advanced water purification systems and air filters that can remove pollutants at the nanoscale.

4. Materials Science: The ability to manipulate matter at the nanoscale has led to the creation of materials with enhanced properties, such as increased strength, flexibility, and conductivity. Carbon nanotubes and graphene are prime examples of nanomaterials with exceptional mechanical and electrical properties. These materials have applications in aerospace, automotive, construction, and many other industries.



5. Consumer Products: Nanotechnology is also making its way into everyday consumer products, including cosmetics, textiles, and food packaging. For instance, nanoscale additives can improve the UV protection and durability of sunscreens, while antimicrobial nanocoatings can extend the shelf life of food products by preventing bacterial growth.



Despite its vast potential, nanotechnology also poses challenges and raises ethical considerations. The long-term health and environmental impacts of nanoparticles are still not fully understood, necessitating thorough research and regulation. Additionally, the ethical implications of manipulating matter at such a fundamental level require careful consideration, particularly in terms of privacy, security, and equity.

The future of nanotechnology is incredibly promising, with ongoing research and development expected to yield even more groundbreaking innovations. As scientists and engineers continue to explore the nanoscale, new applications and possibilities will emerge, further transforming industries and improving quality of life.

In conclusion, nanotechnology represents a frontier of science and engineering that holds the potential to revolutionize various aspects of our lives. By harnessing the

unique properties of matter at the nanoscale, we can develop innovative solutions to some of the most pressing challenges facing humanity today.

b) Translate the italicized paragraphs into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

2. Synonym Groups for Physics Vocabulary:

Select 5 key terms from the text. For each term, create a list of 2 to 6 synonyms that capture the same or similar meanings within the context of physics. Below are examples to learn and to guide you:

1. Nanotechnology — Nanoengineering — Nanoscience — Nanotech - Molecular engineering

2. Manipulation — Control — Handling — Alteration – Modification

3. Nanometer — Nanometre — nm - One-billionth of a meter - Tiny scale

4. Semiconductor - Conductive material - Semiconductor material - Integrated circuit base - Transistor foundation

5. Nanoparticles - Nano-sized particles — Nanoclusters — Nanograins – Nanoobjects

6. Diagnostic Tools - Diagnostic devices - Testing tools - Diagnostic instruments - Medical diagnostic equipment

7. Miniaturization — Downsizing - Reduction in size — Shrinking – Compacting

8. Nanoscale Sensors - Nano sensors - Tiny sensors - Molecular sensors - Miniature sensors

9. Materials Science - Material engineering - Material studies - Material technology - Material research

10. Ethical Considerations - Moral considerations - Ethical issues - Ethical concerns - Ethical implications

3. Using the dictionary transcribe and translate the words:

Word	Transcription	Translation
molecular		
nanometer		
diameter		
myriad		
precisely		
efficacy		
miniaturization		
efficient		
purification		
conductivity		
aerospace		
durability		
antimicrobial		
equity		
exceptional		

4. Match the words with their definition:

1. Manipulation	a) To bring about a significant and fundamental change in a field or industry, often through innovative methods or technologies.
2. Nanometer	b) The ability to accomplish a task or produce a result with

	the least amount of wasted resources, effort, or energy.
3. Revolutionize	c) Having the ability to kill or inhibit the growth of microorganisms, such as bacteria, viruses, and fungi.
4. Diagnosis	d) The action of controlling or influencing something in a skillful manner, often for a specific purpose.
5. Miniaturization	e) Capable of bending easily without breaking; adaptable to change or variation.
6. Efficiency	f) The process of making something much smaller in size, particularly in the context of electronic components and devices.
7. Purification	g) To improve or augment something, making it better in quality, value, or effectiveness.
8. Flexible	h) A unit of measurement equal to one-billionth of a meter, commonly used to measure objects and distances at the atomic and molecular scale.
9. Enhanced	i) The process of removing impurities or contaminants from a substance, making it clean and pure.
10. Antimicrobial	j) The identification of the nature and cause of a disease or condition, typically through examination and testing.

5. Give English equivalents to the meanings of the following words and word combinations:

галузь науки та техніки, що швидко розвивається	
в атомному та молекулярному масштабі	

одна мільярдна частина метра	
унікальні властивості матеріалів	
в основі нанотехнологій	
цільова доставка ліків	
інструменти діагностики	
побічні ефекти	
нанорозмірні датчики	
обчислювальна потужність та ефективність	
нанорозмірні транзистори	
потужні комп'ютери	
вирішальна роль	
виробництво, зберігання та збереження енергії	
сонячні батареї	
система очищення води	
забруднюючі речовини	
гнучкість	
провідність	
механічні та електричні властивості	
нанорозмірні добавки	
захист від УФ-випромінювання	
антимікробні нанопокриття	

6. Find synonyms to the words:

1. Transform -
2. Fundamentals -
3. Precise -
4. Fabricate -
5. Diagnosis -
6. Innovate -
7. Application -
8. Revolutionize -
9. Capability -
10. Prospect -

7. Choose the correct answer:

1. What is the primary focus of nanotechnology?

- A) Manipulating and controlling matter on a microscopic scale
- B) Creating large-scale industrial machinery
- C) Developing new agricultural techniques
- D) Exploring outer space

2. What unit of measurement is commonly used in nanotechnology?

- A) Centimeter
- B) Millimeter
- C) Nanometer
- D) Kilometer

3. How can nanoparticles be used in medicine?

- A) To build new infrastructure

- B) To enable targeted drug delivery systems
- C) To create fossil fuels
- D) To design new fashion trends

4. What role does nanotechnology play in electronics and computing?

- A) Reducing food waste
- B) Improving the efficiency of solar panels
- C) Miniaturizing electronic components and increasing computing power
- D) Enhancing agricultural yields

5. Which of the following is an application of nanotechnology in the energy sector?

- A) Building skyscrapers
- B) Enhancing fuel cell efficiency
- C) Developing new flavors for food
- D) Printing books

6. What is a major challenge associated with nanotechnology?

- A) Lack of interest from scientists
- B) Long-term health and environmental impacts
- C) Difficulty in finding funding for research
- D) Limited applications in real-world scenarios

7. What is one way nanotechnology can improve consumer products?

- A) By increasing the shelf life of food products through antimicrobial nanocoatings
- B) By creating new genres of music
- C) By developing faster internet connections
- D) By designing new architectural styles

8. What is a potential ethical consideration related to nanotechnology?

- A) The taste of new food products
- B) Privacy and security concerns
- C) The popularity of nanotechnology among teenagers

D) The aesthetics of nanotechnology devices

9. Which is the best way to translate the following sentence:

Nanotechnology involves the manipulation of matter on an atomic and molecular scale.

A) Нанотехнологія включає маніпуляції з матерією на атомарному та молекулярному рівнях.

B) Нанотехнологія охоплює вивчення планет і зірок.

C) Нанотехнологія займається створенням великих будівельних споруд.

D) Нанотехнологія фокусується на вивченні кліматичних змін.

10. Which is the best way to translate the following sentence:

Nanoparticles can be engineered to deliver drugs directly to cancer cells.

A) Наночастинки можна розробити для доставки ліків безпосередньо до ракових клітин.

B) Наночастинки використовуються для будівництва великих мостів.

C) Наночастинки можуть допомогти в утилізації відходів.

D) Наночастинки слугують для покращення якості повітря.

8. Translate the following sentences into Ukrainian:

1. Nanotechnology enables the creation of materials with enhanced properties that are not possible at the macroscopic scale.

2. Researchers are developing nanoparticles that can target and destroy cancer cells with minimal side effects.

3. Advancements in nanotechnology are revolutionizing the electronics industry by enabling the production of more powerful and energy-efficient devices.

4. Nanomaterials such as graphene and carbon nanotubes have exceptional mechanical and electrical properties, making them valuable in various industries.

5. Ethical considerations in nanotechnology include assessing the long-term health and environmental impacts of nanoparticles.

9. Translate the following sentences into English:

1. Нанотехнології дозволяють створювати високоефективні батареї з тривалим терміном служби та швидким заряджанням.
2. Розробка наноматеріалів з антимікробними властивостями допомагає зменшити поширення інфекцій у медичних закладах.
3. Нанороботи можуть бути використані для проведення складних хірургічних процедур з мінімальним ризиком для пацієнтів.
4. Застосування нанотехнологій у виробництві сонячних панелей дозволяє підвищити їх ефективність у перетворенні сонячної енергії на електрику.
5. Нанотехнології відкривають нові можливості для створення легких та міцних матеріалів для будівництва та транспорту.

10. Answer the questions to the text?

1. What is nanotechnology and at what scale does it operate?
2. How can nanoparticles be used in medicine to improve treatment?
3. What role does nanotechnology play in the development of electronics and computing?
4. How does nanotechnology contribute to the creation of more efficient energy sources?
5. What materials with exceptional properties have been created using nanotechnology?
6. Which industries use nanotechnology to improve their products and processes?
7. What are the main advantages of using nanotechnology in everyday consumer products?
8. What challenges and ethical issues arise with the use of nanotechnology?
9. How can nanotechnology help address environmental problems?
10. What are the future prospects of nanotechnology and how might it impact various industries?

11. Write a short summary of the text (See the scheme in the Information File – ex.11 p. 16) and be ready to present it.

S P E A K I N G

1. Guidelines for Discussion (Suggestions for Discussion):

1. Explore the Applications of Nanotechnology:

Discuss the various applications of nanotechnology in different fields such as medicine, electronics, energy, materials science, and consumer products. How has nanotechnology transformed these industries? Provide specific examples to illustrate the impact of nanoscale innovations.

2. Evaluate the Ethical Implications of Nanotechnology:

Analyze the ethical considerations related to the use of nanotechnology. What are the potential risks and benefits of manipulating matter at the nanoscale? Discuss issues such as privacy, security, environmental impact, and long-term health effects. How can these challenges be addressed through regulation and responsible innovation?

3. Investigate Technological Advancements in Nanotechnology:

Examine the latest technological advancements in nanotechnology. How have recent innovations improved the efficiency, effectiveness, and scalability of nanotechnology applications? Explore developments such as targeted drug delivery systems, nanoscale sensors, and advanced nanomaterials. What future advancements can we expect?

4. Discuss the Economic Impact of Nanotechnology:

Evaluate the economic implications of nanotechnology. How does the development and commercialization of nanotechnology influence job creation, industry growth, and global competitiveness? Consider both the short-term and long-term economic impacts of nanotechnology across various sectors.

5. Consider the Future Prospects of Nanotechnology:

Reflect on the future prospects and potential of nanotechnology. How might continued advancements in nanotechnology shape the future of science, technology, and society? Discuss emerging trends, potential breakthroughs, and the role of interdisciplinary collaboration in driving nanotechnology forward.

2. Translate the following text into English:

- a) Express the main idea of the text in one sentence;**
- b) Write a short summary of the text in English and present it.**

Вплив нанотехнологій на збереження довкілля

Сучасні нанотехнології відкривають нові можливості для збереження довкілля та боротьби зі змінами клімату. Використання наноматеріалів у системах очищення води дозволяє ефективно видаляти забруднюючі речовини, такі як важкі метали та органічні забруднювачі. Нанофільтри здатні фільтрувати навіть найдрібніші частинки, забезпечуючи чисту та безпечну воду для споживання.

Однією з ключових областей застосування нанотехнологій є розробка нових матеріалів для енергозбереження та підвищення ефективності використання енергії. Наприклад, наноматеріали використовуються для створення більш ефективних сонячних панелей та батарей, що дозволяє зберігати більше енергії та зменшувати втрати. Це сприяє зниженню викидів парникових газів та зменшенню залежності від викопних видів палива.

Крім того, нанотехнології можуть бути використані для моніторингу та зниження рівня забруднення повітря. Наночастинки в каталізаторах дозволяють підвищити ефективність очищення вихлопних газів автомобілів та промислових підприємств, зменшуючи рівень шкідливих викидів. Такі технології мають потенціал значно покращити якість повітря в містах і знизити ризики для здоров'я населення.

В майбутньому нанотехнології можуть стати важливим інструментом для збереження довкілля та сталого розвитку. Завдяки постійним дослідженням та інноваціям, ми можемо очікувати появу нових рішень, які допоможуть зберегти нашу планету для майбутніх поколінь.

EXTENDED READING *

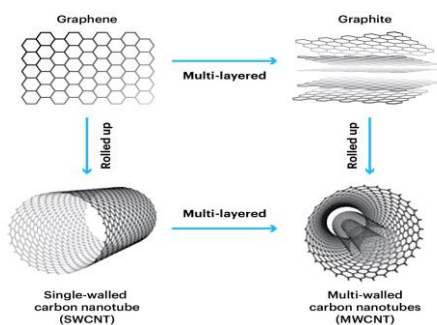
1.1* Read and translate the following texts Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Text 1

The Fascinating World of Carbon Nanotubes

Carbon nanotubes (CNTs) are cylindrical nanostructures composed of carbon atoms arranged in a hexagonal lattice. These remarkable materials have captivated scientists and engineers due to their extraordinary mechanical, electrical, and thermal properties. Discovered in the early 1990s, carbon nanotubes have since become a focal point of research and innovation, with applications spanning a wide range of industries.

Structure and Properties. Carbon nanotubes come in two primary forms: single-



walled nanotubes (SWCNTs) and multi-walled nanotubes (MWCNTs). SWCNTs consist of a single layer of carbon atoms rolled into a cylinder, while MWCNTs comprise multiple concentric layers. The unique structure of CNTs

imparts several exceptional properties:

1. Mechanical Strength: Carbon nanotubes are incredibly strong and lightweight. They possess a tensile strength up to 100 times greater than that of steel, making them ideal for reinforcing composite materials.

2. Electrical Conductivity: CNTs can exhibit metallic or semiconducting behavior depending on their chirality (the angle at which the graphene sheet is rolled). This makes them valuable for use in nanoscale electronic devices, transistors, and conductive films.

3. Thermal Conductivity: Carbon nanotubes have excellent thermal conductivity, surpassing that of diamond. This property makes them suitable for applications requiring efficient heat dissipation, such as thermal management in electronic devices.

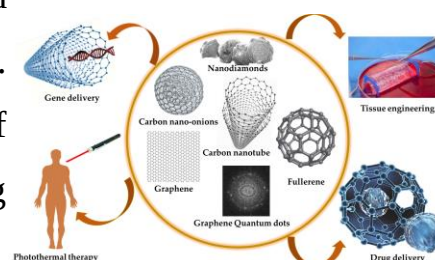
Application. The exceptional properties of carbon nanotubes have led to their exploration in various fields:

1. Electronics: Carbon nanotubes are used to develop next-generation transistors, sensors, and flexible electronic circuits. Their ability to conduct electricity efficiently and their nanoscale dimensions make them ideal for miniaturized electronic devices.

2. Materials Science: CNTs are incorporated into composite materials to enhance their mechanical strength and durability. For instance, adding CNTs to polymers, metals, and ceramics can significantly improve their performance in aerospace, automotive, and construction applications.

3. Energy Storage: Carbon nanotubes are being researched for their potential in energy storage devices such as batteries and supercapacitors. Their high surface area and excellent electrical conductivity can improve the efficiency and capacity of these devices.

4. Medical and Biotechnology: CNTs are explored for drug delivery systems, biosensors, and imaging agents. Their unique properties allow for targeted delivery of therapeutic agents, enhanced sensitivity in detecting



biological molecules, and improved imaging contrast in medical diagnostics.

5. Environmental Applications: Carbon nanotubes are used in water purification systems and air filters. Their high surface area and adsorption capacity enable them to remove contaminants and pollutants effectively.

Challenges and Future Prospects. Despite their promising properties, carbon nanotubes face challenges such as high production costs, difficulties in achieving uniformity, and concerns about their environmental and health impacts. Ongoing research aims to address these issues by developing cost-effective synthesis methods, improving the consistency of CNTs, and assessing their safety.

The future of carbon nanotubes is incredibly promising. As research and development continue to advance, CNTs are expected to play an increasingly significant role in various technological innovations, from advanced electronics to sustainable energy solutions.

In conclusion, carbon nanotubes represent a frontier of materials science with the potential to revolutionize multiple industries. Their extraordinary properties and versatile applications make them a key component in the quest for new and improved technologies.

1.2* Comprehension Questions:

1. What are carbon nanotubes and what are their primary forms?
2. Explain the mechanical, electrical, and thermal properties of carbon nanotubes.
3. How are carbon nanotubes used in the field of electronics?
4. Describe the role of carbon nanotubes in energy storage devices.
5. What are the main challenges associated with the production and use of carbon nanotubes?

1.3* Vocabulary and Terminology:

a) Define the following terms	b) Match the terms to their definitions
1. Carbon nanotubes (CNTs)	a) Cylindrical nanostructures composed of carbon atoms in a hexagonal lattice.
2. Single-walled nanotubes (SWCNTs)	b) A property that determines whether a carbon nanotube exhibits metallic or semiconducting behavior.
3. Multi-walled nanotubes (MWCNTs)	c) Carbon nanotubes that consist of a single layer of carbon atoms rolled into a cylinder.
4. Tensile strength	d) The resistance of a material to breaking under tension.
5. Chirality	e) Carbon nanotubes that have multiple concentric layers of carbon atoms.

1.4* Write a brief summary of the text in your own words in 5-6 sentences.

1.5* Discussion Prompts:

1. Discuss the potential applications of carbon nanotubes in various industries.

How can their unique properties be leveraged for technological advancements?

2. Explore the economic impact of incorporating carbon nanotubes into materials science. How might CNTs influence the manufacturing and performance of composite materials?

3. Reflect on the ethical and environmental considerations associated with the production and use of carbon nanotubes. What measures can be taken to ensure their safe and responsible use?

4. Debate the challenges and potential solutions in the large-scale production of carbon nanotubes. How can researchers and engineers overcome these obstacles to make CNTs more accessible?

5. Analyze the future prospects of carbon nanotubes. What emerging trends and innovations could further expand their applications and impact?

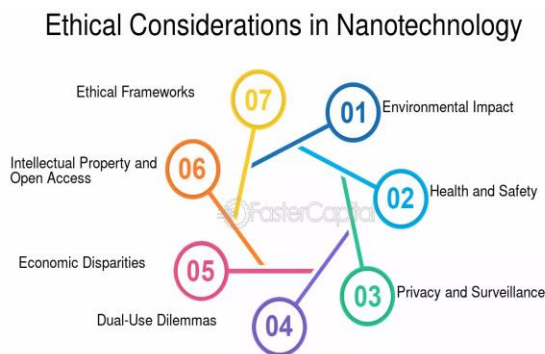
1.6* Research and Presentation:

Compare and contrast carbon nanotubes with another nanomaterial, such as graphene. Highlight the advantages and limitations of each. Prepare a presentation to explain your analysis and provide recommendations based on your research.

Text 2

2.1* Read and translate the following texts Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Ethical Considerations of Nanotechnology



Nanotechnology, the science and engineering of manipulating matter at the nanoscale, holds immense potential for innovation across a wide range of fields, including medicine, electronics, energy, and materials science. However, alongside its promising applications, nanotechnology also

raises important ethical considerations that must be addressed to ensure its responsible development and use.

One of the primary ethical concerns surrounding nanotechnology is the potential impact on human health and safety. Nanoparticles, due to their small size, can easily

penetrate biological membranes and accumulate in tissues and organs. The long-term effects of exposure to nanoparticles are not yet fully understood, and there is a need for comprehensive research to evaluate their toxicity and biocompatibility. Ensuring the safety of workers involved in the production and handling of nanomaterials is also crucial. Ethical considerations demand stringent safety standards and regulations to protect both the public and the environment from potential risks associated with nanotechnology.

The environmental implications of nanotechnology are another significant ethical concern. The production, use, and disposal of nanomaterials can result in the release of nanoparticles into the environment, where they may interact with ecosystems in unpredictable ways. The potential for nanoparticles to cause harm to wildlife, soil, and water systems must be thoroughly investigated. Developing sustainable practices for the lifecycle management of nanomaterials, including recycling and safe disposal, is essential to minimize their environmental footprint. Ethical stewardship requires a proactive approach to understanding and mitigating the environmental impact of nanotechnology.

Nanotechnology-enabled devices, such as nanoscale sensors and surveillance technologies, raise ethical questions related to privacy and security. The ability to collect and transmit vast amounts of data at the nanoscale introduces the potential for misuse and unauthorized access to personal information. Ensuring that the deployment of such technologies respects individuals' privacy rights and adheres to ethical standards is paramount. Robust safeguards and transparent policies must be established to protect against privacy infringements and ensure that nanotechnology is used in a manner that upholds ethical principles.

The equitable distribution of the benefits of nanotechnology is another critical ethical consideration. There is a risk that advanced nanotechnology applications may disproportionately benefit affluent individuals and communities, exacerbating existing social and economic inequalities. Ensuring that the advantages of nanotechnology, such

as improved medical treatments and sustainable energy solutions, are accessible to all segments of society is essential. Ethical considerations call for policies and initiatives that promote inclusivity and equitable access to nanotechnology's benefits, regardless of socioeconomic status.

The rapid pace of nanotechnology development necessitates robust regulatory frameworks and governance structures to address its ethical implications. Policymakers, scientists, industry leaders, and the public must collaborate to establish guidelines and regulations that ensure the responsible development and use of nanotechnology. This includes ethical oversight, public engagement, and transparency in decision-making processes. By fostering a culture of ethical responsibility, society can harness the potential of nanotechnology while safeguarding against its potential risks.

In conclusion, the ethical considerations of nanotechnology encompass a wide range of issues, from health and safety to environmental impact, privacy, equity, and governance. Addressing these ethical concerns is crucial to ensuring the responsible and sustainable development of nanotechnology. By prioritizing ethical principles and engaging in interdisciplinary collaboration, society can unlock the transformative potential of nanotechnology while upholding the values of safety, equity, and environmental stewardship.

2.2* Comprehension Questions:

1. What are the primary health and safety concerns associated with nanotechnology?
2. How can the environmental impact of nanotechnology be minimized?
3. What privacy and security issues are raised by nanotechnology-enabled devices?
4. Why is it important to ensure equitable access to the benefits of nanotechnology?

5. What role do regulatory frameworks play in addressing the ethical implications of nanotechnology?

2.3* Vocabulary and Terminology:

a) Define the following terms	b) Match the terms to their definitions
1. Nanoparticles	a) Tiny particles measured in nanometers, often used in nanotechnology applications.
2. Biocompatibility	b) The ability of a material to be compatible with living tissue without causing harm.
3. Ecosystems	c) Communities of living organisms interacting with their physical environment.
4. Surveillance technologies	d) Technologies used to monitor and collect data, often raising privacy concerns.
5. Equity	e) Fairness in the distribution of resources and opportunities.

2.4* Summarize the text in your own words in 5-6 sentences.

2.5* Discussion Prompts:

1. Discuss the potential health risks associated with the exposure to nanoparticles. How can researchers ensure the safety of workers and the public?

2. Explore the environmental challenges posed by nanotechnology. What sustainable practices can be implemented to mitigate these impacts?

3. Reflect on the ethical considerations related to privacy and security in nanotechnology. How can we balance technological advancement with the protection of personal information?

4. Debate the importance of equitable access to nanotechnology's benefits. What measures can be taken to prevent social and economic disparities?

5. Analyze the role of regulation and governance in the responsible development of nanotechnology. What policies and guidelines should be established to address ethical concerns?

2.6* *Research and Presentation:*

Investigate emerging trends and potential future ethical considerations in nanotechnology. What new challenges might arise as nanotechnology continues to advance? Present your findings and discuss possible solutions.

UNIT X

ASTROPHYSICS AND THE UNIVERSE

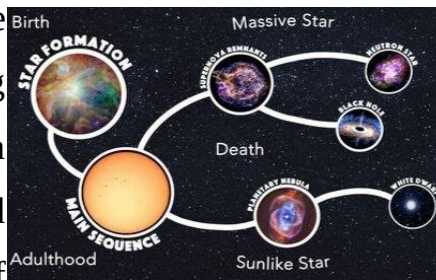
TEXT

Astrophysics and the Marvels of the Universe

1. a) Read and translate the text using the dictionary:

Astrophysics, the branch of astronomy that deals with the physics of celestial objects and phenomena, seeks to understand the fundamental nature of the universe. From the birth of stars to the mysteries of black holes, astrophysics explores the vast and awe-inspiring cosmos, revealing the intricate workings of the universe and our place within it.

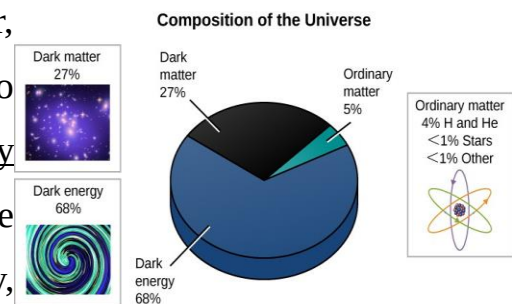
The Birth and Death of Stars. Stars are the fundamental building blocks of galaxies, and understanding their life cycles is crucial to comprehending the evolution of the universe. Stars are born in vast clouds of gas and dust, known as nebulae, through the process of gravitational collapse. As the material within a nebula contracts, it heats up and eventually ignites nuclear fusion in the core, giving birth to a new star. Throughout their lifetimes, stars undergo various stages, from the main sequence to the red giant phase, ultimately culminating in either a supernova explosion or the shedding of outer layers to form a white dwarf, neutron star, or black hole.



The Enigmatic Black Holes. Black holes are among the most mysterious and fascinating objects in the universe. Formed from the remnants of massive stars that have undergone

supernova explosions, black holes are regions of space where gravity is so intense that nothing, not even light, can escape. The boundary surrounding a black hole, known as the event horizon, marks the point of no return. Inside a black hole, the laws of physics as we know them break down, making them a subject of intense study and speculation. Black holes play a crucial role in shaping galaxies and influencing the behavior of nearby matter, offering profound insights into the nature of space and time.

Dark Matter and Dark Energy. Despite significant advancements in astrophysics, much of the universe remains a mystery. One of the greatest enigmas is the existence of dark matter and dark energy. Dark matter, which does not emit or absorb light, is believed to make up about 27% of the universe's mass-energy content. It exerts gravitational forces that affect the motion of galaxies and galaxy clusters. Dark energy, on the other hand, is thought to be responsible for the accelerated expansion of the universe, accounting for approximately 68% of the universe's mass-energy content. Understanding these elusive components is essential for unraveling the true nature and fate of the universe.

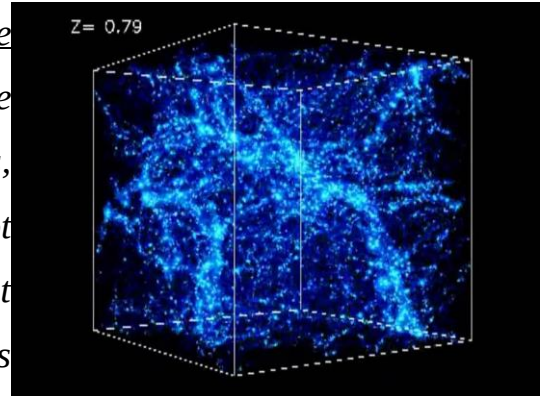


Exploring Exoplanets. The discovery of exoplanets, planets orbiting stars outside



our solar system, has revolutionized our understanding of the universe. Astrophysicists have identified thousands of exoplanets, some of which reside in the habitable zones of their parent stars, where conditions may be suitable for life as we know it. Advanced telescopes and observational techniques have enabled scientists to study the atmospheres, compositions, and potential habitability of these distant worlds. The search for extraterrestrial life and the study of exoplanets offer exciting possibilities for discovering new forms of life and expanding our knowledge of planetary systems.

The Cosmic Web. *The universe is structured on a vast scale, with galaxies forming intricate networks known as the cosmic web. This web-like structure consists of filaments, clusters, and voids, spanning billions of light-years. Galaxies are not randomly distributed but are organized into this vast cosmic tapestry. Studying the cosmic web provides valuable insights into the large-scale structure of the universe, the formation and evolution of galaxies, and the distribution of dark matter. Understanding the cosmic web is essential for developing comprehensive models of the universe's origin and evolution.*



Astrophysics is a field that continually pushes the boundaries of human knowledge and imagination. By exploring the mysteries of the universe, from the birth and death of stars to the enigmatic nature of black holes, dark matter, and dark energy, astrophysics provides profound insights into the fundamental workings of the cosmos. The discovery of exoplanets and the study of the cosmic web further enrich our understanding of the universe and our place within it. As we continue to unravel the secrets of the universe, astrophysics will remain at the forefront of scientific discovery, inspiring wonder and curiosity for generations to come.

b) Translate the italicized paragraphs into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

2. Synonym Groups for Physics Vocabulary:

Select 5 key terms from the text. For each term, create a list of 2 to 6 synonyms that capture the same or similar meanings within the context of physics. Below are examples to learn and to guide you:

1. **Astrophysics** - Astronomy - Celestial science - Space physics – Cosmology
2. **Celestial objects** - Heavenly bodies - Astronomical bodies - Cosmic entities - Stellar objects
3. **Gravitational collapse** - Gravitational contraction - Collapse due to gravity - Gravitational implosion - Gravity-induced collapse
4. **Nuclear fusion** - Atomic fusion - Fusion reaction - Nuclear combination - Fusion process
5. **Black holes** — Singularities - Space-time singularities - Gravitational wells - Cosmic voids
6. **Dark matter** - Invisible matter - Non-luminous matter - Hidden mass - Mysterious matter
7. **Dark energy** - Anti-gravitational force - Cosmic repulsion - Mysterious energy - Energy causing expansion
8. **Exoplanets** - Extrasolar planets - Alien planets - Otherworldly planets - Planets beyond the solar system
9. **Cosmic web** - Universe's large-scale structure - Galactic network - Celestial network - Intergalactic web
10. **Nebulae** - Gas clouds - Star-forming regions - Interstellar clouds - Stellar nurseries

3. Using the dictionary transcribe and translate the words:

Word	Transcription	Translation
celestial objects		
awe-inspiring		

intricate workings		
cycles		
nebulae		
neutron		
remnants		
horizon		
advancements		
exert		
expansion		
unravel		
reside		
suitable		
extraterrestrial life		

4. Match the words with their definition:

1. Cosmos	A type of compact star composed mostly of neutrons, formed by the gravitational collapse of a massive star after a supernova explosion.
2. Main sequence	The property of being compatible with living tissue without causing harm.
3. Red giant	The resistance of a material to breaking under tension.
4. White dwarf	A continuous and distinctive band of stars that appears on

	plots of stellar color versus brightness. Most stars, including the sun, are main-sequence stars.
5. Neutron star	Groups of galaxies held together by gravitational forces, often containing hundreds or thousands of galaxies.
6. Habitable zone	A late phase in a star's life cycle where it expands and cools after using up its hydrogen fuel.
7. Tensile strength	Regions in space where gas and dust are contracting under gravity to form new stars, often seen as nebulae.
8. Biocompatibility	The universe seen as a well-ordered, harmonious whole.
9. Stellar nurseries	A small, dense star that is the remnants of a low or medium mass star after it has expended all its central nuclear fuel and lost its outer layers.
10. Galaxy clusters	The region around a star where conditions may be suitable for life as we know it, typically where liquid water can exist.

5. Give English equivalents to the meanings of the following words and word combinations:

небесні об'єкти	
туманності	
ядерний синтез	
наднова	
чорні діри	

темна матерія	
природа Всесвіту	
величезний і вражаючий космос	
хмари газу та пилу	
стискатися	
нагріватися	
проходити різні стадії	
червоний гігант	
вибух	
нейтронна зірка	
залишки зірок	
зазнавати вибухів	
гравітація	
точка неповернення	
порушувати закони фізики	
світлові роки	
за межами Сонячної системи	
придатний для життя	
позаземне життя	

6. Find synonyms to the words:

1. Expand -

2. Accelerate -

- 3. Fundamental -
- 4. Phenomena -
- 5. Cosmos -
- 6. Mysteries -
- 7. Insights -
- 8. Significant -
- 9. Reveal -
- 10. Structure:
- 11. Vast -
- 12. Ignite -

7. Choose the correct answer:

1. What initiates the birth of a new star?

- A) The collision of two black holes
- B) The gravitational collapse of a nebula
- C) The explosion of a supernova
- D) The merging of galaxies

2. What marks the boundary surrounding a black hole?

- A) The singularity
- B) The Schwarzschild radius
- C) The event horizon
- D) The accretion disk

3. What is believed to make up about 27% of the universe's mass-energy content?

- A) Dark energy
- B) Ordinary matter
- C) Cosmic rays
- D) Dark matter

4. What accounts for the accelerated expansion of the universe?

- A) Dark matter
- B) Neutron stars
- C) Dark energy
- D) Black holes

5. What are exoplanets?

- A) Planets within our solar system
- B) Dwarf planets
- C) Planets orbiting stars outside our solar system
- D) Planets that have collided with other planets

6. Which region around a star may have conditions suitable for life?

- A) The red giant zone
- B) The habitable zone
- C) The neutron star zone
- D) The black hole zone

7. What is the structure of the universe on a vast scale called?

- A) The galactic core
- B) The cosmic web
- C) The event horizon
- D) The dark matter halo

8. What type of star is formed from the remnants of a low or medium mass star?

- A) Neutron star
- B) Black hole
- C) Red giant
- D) White dwarf

9. Which is the best way to translate the following sentence:

Astrophysics seeks to understand the fundamental nature of the universe.

- A) Астрофізика прагне зрозуміти основоположну природу Всесвіту.

- B) Астрофізика вивчає рух планет в Сонячній системі.
- C) Астрофізика досліджує метеорологічні явища.
- D) Астрофізика зосереджується на вивченні кліматичних змін.

10. Which is the best way to translate the following sentence:

The discovery of exoplanets has revolutionized our understanding of the universe.

- A) Відкриття екзопланет змусило нас переглянути наше розуміння фізики.
- B) Відкриття екзопланет відкрило нові горизонти в технологіях.
- C) Відкриття екзопланет стало революційним для нашого розуміння Всесвіту.
- D) Відкриття екзопланет розширило наші знання про атмосферні явища.

8. Translate the following sentences into Ukrainian:

1. The intricate life cycle of stars, from their formation in nebulae to their dramatic death as supernovae, reveals much about the evolution of galaxies.

2. Astrophysicists utilize advanced telescopes to observe distant exoplanets and study their potential to harbor life.

3. The mysterious nature of dark matter and dark energy continues to challenge scientists, as they seek to understand these elusive components of the cosmos.

4. Black holes, with their immense gravitational pull, can significantly influence the motion and behavior of nearby celestial objects.

5. The cosmic web, an extensive network of galaxies and filaments, provides valuable insights into the large-scale structure of the universe.

9. Translate the following sentences into English:

1. Дослідження темної матерії дозволяє вченим краще розуміти гравітаційні взаємодії у великих масштабах Всесвіту.

2. Сучасні телескопи допомагають астрономам виявляти нові екзопланети та аналізувати їхні атмосфери.

3. Зоряні туманності є регіонами інтенсивного зореутворення, де народжуються нові світила.

4. Темна енергія відіграє ключову роль у прискореному розширенні Всесвіту, що залишається однією з найбільших загадок космології.

5. Галактики формують складну космічну павутину, що включає філаменти і скупчення, які утворюють масштабну структуру Всесвіту.

10. Answer the questions to the text?

1. What is the primary focus of astrophysics?
2. How are stars born within nebulae?
3. What are the main stages in the life cycle of a star?
4. How do black holes form from the remnants of massive stars?
5. What is the significance of the event horizon in a black hole?
6. What percentage of the universe's mass-energy content is believed to be dark matter?
7. How does dark energy influence the expansion of the universe?
8. What are exoplanets, and why are they significant in astrophysics?
9. Describe the structure of the cosmic web and its importance in understanding the universe.
10. What role do advanced telescopes play in the study of distant exoplanets?

11. Write a short summary of the text (See the scheme in the Information File – ex.11 p. 16) and be ready to present it.

S P E A K I N G

1. Guidelines for Discussion:

1. Exploring the Life Cycle of Stars:

Discuss the various stages in the life cycle of stars, from their formation in nebulae to their final stages as white dwarfs, neutron stars, or black holes. What processes drive these transformations, and how do they impact the surrounding interstellar medium?

2. Understanding Black Holes:

Analyze the nature of black holes, including their formation, structure, and the concept of the event horizon. How do black holes influence the behavior of nearby matter and light? What are the current theories and observations about what happens beyond the event horizon?

3. Investigating Dark Matter and Dark Energy:

Explore the mysteries of dark matter and dark energy. What evidence supports their existence, and what role do they play in the structure and evolution of the universe? Discuss the methods used by astrophysicists to study these elusive components and the challenges they face.

4. The Search for Exoplanets:

Discuss the discovery and study of exoplanets. What techniques are used to detect and characterize exoplanets? What have we learned about their diversity and potential habitability? How does the search for exoplanets contribute to our understanding of planetary systems and the possibility of extraterrestrial life?

5. The Cosmic Web and Large-Scale Structure of the Universe:

Examine the concept of the cosmic web and its significance in astrophysics. How are galaxies distributed within this vast network, and what does it reveal about the formation and evolution of the universe? Discuss the role of dark matter in shaping the large-scale structure of the cosmos.

2. Translate the following text into English:

- a) Express the main idea of the text in one sentence;**
- b) Write a short summary of the text in English and present it.**

Великі загадки астрофізики

Астрофізика є науковою галуззю, що вивчає фізичну природу небесних об'єктів та явищ, намагаючись розкрити фундаментальні закони Всесвіту. Однією з найбільших загадок астрофізики є природа темної матерії і темної енергії. Темна матерія, яка не випромінює і не поглинає світла, становить приблизно 27% маси-енергії Всесвіту. Вона впливає на рух галактик і їхніх скупчень завдяки своїм гравітаційним силам. Темна енергія, яка складає близько 68% маси-енергії Всесвіту, відповідає за прискорене розширення космосу.

Дослідження чорних дір залишається однією з найцікавіших тем астрофізики. Чорні діри утворюються з решток масивних зірок після їхніх наднових вибухів. Вони мають настільки потужну гравітаційну силу, що ніщо, навіть світло, не може уникнути їхнього тяжіння. Подіячний горизонт чорної діри відзначає точку неповернення, після якої звичайні фізичні закони перестають діяти. Вивчення чорних дір допомагає розкрити таємниці простору і часу.

Останніми роками астрофізика значно просунулася в дослідженні екзопланет – планет, що обертаються навколо зірок за межами нашої Сонячної системи. Використовуючи сучасні телескопи, вчені виявили тисячі екзопланет, деякі з яких знаходяться в зонах життя своїх зоряних систем. Це відкриття має важливе значення для розуміння різноманітності планетних систем і можливості існування позаземного життя.

Таким чином, астрофізика продовжує розкривати захоплюючі таємниці Всесвіту, вивчаючи життя зірок, чорні діри, темну матерію та енергію, а також екзопланети. Кожне нове відкриття наближає нас до розуміння фундаментальних законів, що керують космосом, та нашого місця в ньому.

EXTENDED READING*

1.1* Read and translate the following texts Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Text 1

Unveiling the Enigma of Dark Energy

Dark energy, a mysterious and pervasive force, is one of the greatest enigmas in modern astrophysics and cosmology. This elusive phenomenon is believed to be responsible for the accelerated expansion of the universe, challenging our understanding of the fundamental forces that govern the cosmos. Despite its profound implications, dark energy remains largely unexplained, sparking a quest to uncover its true nature and origins.

The concept of dark energy emerged from observations of distant supernovae in the late 1990s, which revealed that the universe's expansion was not slowing down, as previously thought, but accelerating. This groundbreaking discovery contradicted the prevailing notion that gravitational forces should gradually decelerate cosmic expansion. Instead, an unknown force appeared to be driving galaxies apart at an ever-increasing rate. Scientists coined the term "dark energy" to describe this mysterious force, which is estimated to constitute approximately 68% of the universe's total mass-energy content.

Dark energy is thought to permeate all of space, exerting a repulsive pressure that counteracts the attractive force of gravity. This repulsive pressure accelerates the expansion of the universe, leading to the observed phenomenon of galaxies moving away from each other at increasing speeds. The precise nature of dark energy remains a subject of intense debate and investigation. Some theories propose that dark energy is a property of space itself, while others suggest it may be related to the vacuum energy predicted by quantum field theory. Alternative explanations include modifications to general relativity or the existence of a new, unknown particle or field.

The study of dark energy poses significant challenges due to its elusive and pervasive nature. Unlike dark matter, which can be detected through its gravitational effects on visible matter, dark energy does not interact with light or other forms of electromagnetic radiation. This makes it incredibly difficult to observe directly. Instead, scientists infer the presence of dark energy through its influence on cosmic expansion and the large-scale structure of the universe. Advanced observational techniques, such as measurements of the cosmic microwave background radiation and large-scale galaxy surveys, are employed to study dark energy's effects and properties.



Unlocking the mysteries of dark energy is a central goal of contemporary cosmology and astrophysics. Future research endeavors, including next-generation space telescopes and precision cosmological surveys, aim to shed light on this enigmatic force. Projects like the Dark Energy Survey (DES) and the European Space Agency's Euclid mission are designed to map the distribution of galaxies and measure cosmic expansion with unprecedented accuracy. These efforts will provide valuable insights into the nature of dark energy and its role in the evolution of the universe.

In conclusion, dark energy represents one of the most profound and challenging puzzles in our quest to understand the cosmos. Its discovery has revolutionized our perception of the universe, prompting a reevaluation of fundamental physical laws and theories. As scientists continue to explore this mysterious force, each new discovery brings us closer to unraveling the secrets of dark energy and the ultimate fate of the universe.

1.2* Comprehension Questions:

1. What is dark energy, and why is it considered one of the greatest enigmas in modern astrophysics?

2. Describe the observations that led to the discovery of dark energy in the late 1990s.
3. How does dark energy influence the expansion of the universe?
4. What are some theories that attempt to explain the nature of dark energy?
5. What challenges do scientists face in studying dark energy?

1.3* Vocabulary and Terminology:

a) Define the following terms	b) Match the terms to their definitions
1. Dark energy	e) Observational studies that aim to map the large-scale structure of the universe.
2. Cosmic expansion	c) The force exerted by dark energy that counteracts gravity.
3. Repulsive pressure	b) The increase in the distance between galaxies over time.
4. Quantum field theory	d) A theoretical framework that describes how fields interact with particles.
5. Cosmological surveys	a) The mysterious force believed to drive the accelerated expansion of the universe.

1.4* Write a brief summary of the text in your own words in 5-6 sentences.

1.5* Discussion Prompts:

1. Discuss the significance of the discovery of dark energy for our understanding of the universe. How did it change our perception of cosmic expansion?
2. Explore the different theories proposed to explain dark energy. Which theory do you find most convincing, and why?

3. Reflect on the challenges faced by scientists in detecting and studying dark energy. What advanced techniques are used to investigate its effects?

4. Debate the potential implications of dark energy for the future of the universe. How might the accelerated expansion influence the ultimate fate of the cosmos?

5. Analyze the role of international collaboration in the study of dark energy. How do global research projects contribute to our understanding of this enigmatic force?

1.6* Research and Presentation:

Investigate emerging technologies and methodologies that could advance the study of dark energy. Discuss how these innovations might help unravel the mysteries of this force and present your findings.

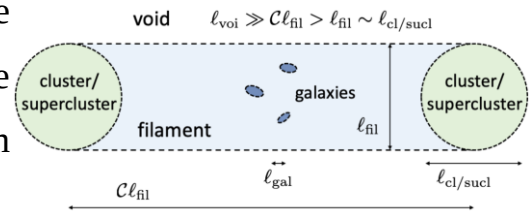
Text 2

2.1* Read and translate the following texts Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

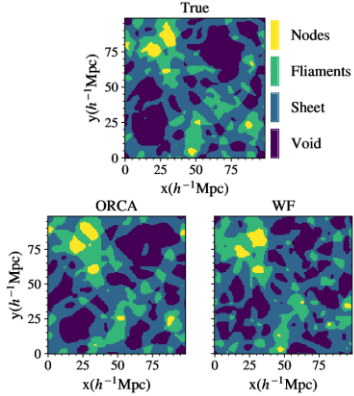
Understanding the Cosmic Web

The cosmic web is a vast and intricate structure that forms the large-scale foundation of the universe. Comprising galaxies, galaxy clusters, and intergalactic filaments, the cosmic web weaves a complex and beautiful tapestry that spans billions of light-years. Understanding this grand design is crucial for unraveling the mysteries of the universe's formation, evolution, and underlying physics.

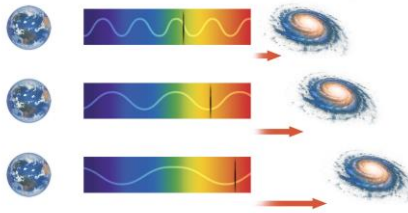
The cosmic web originated shortly after the Big Bang, around 13.8 billion years ago. As the universe expanded and cooled, tiny quantum



fluctuations in the primordial matter evolved into regions of varying density. Gravity pulled matter into these dense regions, creating a network of filaments and voids. Over billions of years, these structures grew and merged, giving rise to the cosmic web we observe today.



The cosmic web consists of three main components: filaments, nodes, and voids. Filaments are elongated structures composed of galaxies, gas, and dark matter, spanning vast distances across the universe. Nodes, located at the intersections of filaments, are regions with a high concentration of galaxies and galaxy clusters. Voids are

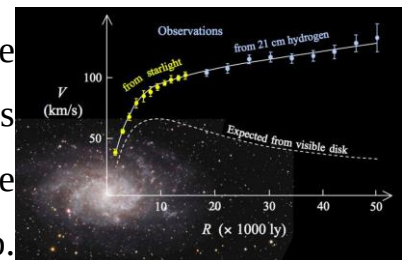


large, relatively empty spaces between filaments, containing very few galaxies. This intricate network forms the scaffolding upon which the universe is built. Studying the cosmic web requires advanced observational techniques and powerful telescopes.

Astronomers use various methods to map and analyze this vast structure. One common approach is galaxy redshift surveys, which measure the redshifts of galaxies to determine their distances and positions in three-dimensional space. By creating detailed maps of galaxy distribution, scientists can trace the underlying structure of the cosmic web.

Additionally, the cosmic microwave background (CMB) radiation provides valuable insights into the early universe and the formation of the cosmic web.

The CMB has highest redshift of **anything** we can see ($z \approx 1000$).



Observations of the CMB reveal the distribution of matter shortly after the Big Bang,

allowing scientists to understand how initial density fluctuations evolved into the web-like structure we see today. Dark matter plays a crucial role in shaping the cosmic web. Although invisible, dark matter exerts gravitational forces that influence the distribution and movement of galaxies. Without dark matter, the cosmic web could not have formed in its current structure. Observations of galaxy rotation curves, gravitational lensing, and large-scale structure formation provide indirect evidence of dark matter's presence and its impact on the cosmic web.

Understanding the cosmic web has profound implications for cosmology and our understanding of the universe's fundamental nature. The distribution and evolution of the cosmic web offer insights into the underlying physics that govern the universe, including the nature of dark matter and dark energy. Studying the cosmic web also helps scientists test and refine theoretical models of cosmic evolution, providing a deeper understanding of the universe's history and future.

The cosmic web is a breathtaking and intricate structure that reveals the grand design of the universe. By studying this vast network of galaxies, filaments, and voids, scientists can gain valuable insights into the formation, evolution, and underlying physics of the cosmos. As observational techniques and technologies continue to advance, our understanding of the cosmic web will continue to grow, unveiling new mysteries and deepening our appreciation of the universe's majestic complexity.

2.2* Comprehension Questions:

1. What is the cosmic web, and what components does it consist of?
2. How did the cosmic web originate after the Big Bang?
3. Describe the main components of the cosmic web: filaments, nodes, and voids.
4. What methods do astronomers use to study and map the cosmic web?
5. How does dark matter influence the structure and formation of the cosmic web?

2.3* Vocabulary and Terminology:

Define the following terms	Match the terms to their definitions
1. Cosmic web	c) Regions at the intersections of filaments with high concentrations of galaxies and clusters.
2. Filaments	e) Invisible matter that exerts gravitational forces, influencing galaxy distribution and movement.
3. Nodes	b) Elongated structures made of galaxies, gas, and dark matter, spanning vast distances.
4. Voids	a) The large-scale structure of the universe, composed of galaxies, galaxy clusters, and intergalactic filaments.
5. Dark matter	d) Large, relatively empty spaces between filaments.

2.4* Summarize the text in your own words in 5-6 sentences.

2.5* Discussion Prompts:

1. Discuss the significance of understanding the cosmic web for cosmology and our knowledge of the universe's formation and evolution.
2. Explore the role of advanced telescopes and observational techniques in mapping the cosmic web. What challenges do astronomers face in studying such a vast structure?
3. Reflect on the importance of dark matter in shaping the cosmic web. How do scientists infer the presence of dark matter through observations?

4. Debate the potential implications of studying the cosmic web for future cosmological theories and models. How might new discoveries reshape our understanding of the universe?

5. Analyze the interplay between filaments, nodes, and voids within the cosmic web. How do these components interact and influence the large-scale structure of the cosmos?

2.6* Research and Presentation:

Conduct research on one of the major observational projects studying the cosmic web, such as the Sloan Digital Sky Survey (SDSS) or the Large Synoptic Survey Telescope (LSST). Prepare a presentation explaining the project's goals, methods, and findings.

UNIT XI

PARTICLE PHYSICS

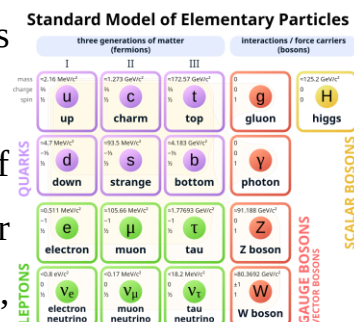
TEXT

The Fascinating World of Particle Physics

1. a) Read and translate the text using the dictionary.

Particle physics is a branch of physics that seeks to understand the fundamental building blocks of the universe and the forces that govern their interactions. It delves into the subatomic realm, exploring the particles that make up atoms and the interactions that bind them together. By studying these tiny particles, physicists aim to unravel the mysteries of the universe's structure and origins.

At the heart of particle physics lies the concept of fundamental particles - those that are not composed of other particles. According to the Standard Model of particle physics, the fundamental particles can be categorized into two main groups: fermions and bosons.



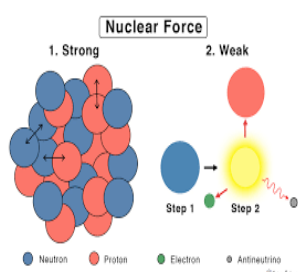
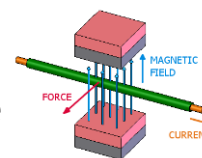
1. Fermions: These particles make up matter. Fermions are further divided into quarks and leptons. Quarks combine to form protons and neutrons, which are the building blocks of atomic nuclei. There are six types of quarks: up, down, charm, strange, top, and bottom. Leptons include electrons, muons, tau particles, and their corresponding neutrinos.

2. Bosons: These particles are force carriers. They mediate the fundamental forces of nature. The four fundamental forces are the electromagnetic force, weak nuclear

force, strong nuclear force, and gravitational force. Each force is associated with its corresponding boson: photons for electromagnetic force, W and Z bosons for weak nuclear force, gluons for strong nuclear force, and the hypothetical graviton for gravitational force.

The Standard Model of particle physics is a theoretical framework that describes the behavior and interactions of fundamental particles. It successfully explains three of the four fundamental forces (excluding gravity) and has been validated by numerous experiments. Key components of the Standard Model include:

1. Electromagnetic Force: Mediated by photons, this force governs the interactions between charged particles and is responsible for phenomena such as electricity and magnetism.



2. Weak Nuclear Force: Mediated by W and Z bosons, this force is responsible for processes such as beta decay in radioactive atoms. It plays a crucial role in nuclear reactions and the synthesis of elements in stars.

3. Strong Nuclear Force: Mediated by gluons, this force binds quarks together to form protons and neutrons. It also holds protons and neutrons together within atomic nuclei, making it essential for the stability of matter.

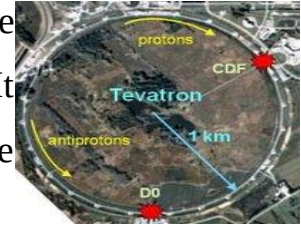
While the Standard Model has been remarkably successful, it does not include gravity, which is described by the theory of general relativity. The search for a theory that unifies all fundamental forces, including gravity, is one of the major goals of modern physics.

To study fundamental particles, physicists use **particle accelerators and colliders**. These machines accelerate particles to extremely high speeds and then collide them, allowing scientists to observe the resulting interactions and particle behavior. Some of the most famous particle accelerators include:

1. Large Hadron Collider: Located at CERN near Geneva, Switzerland, the LHC is the world's largest and most powerful particle collider. It has made significant

discoveries, including the Higgs boson in 2012, which confirmed the existence of the Higgs field responsible for giving particles mass.

2. Tevatron: Located at Fermilab in the United States, the Tevatron was a major particle collider that operated until 2011. It contributed to the discovery of the top quark and advanced the understanding of particle physics.

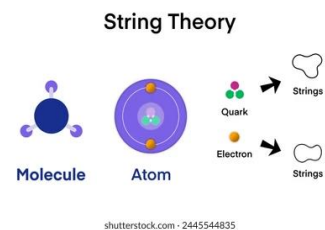


Despite its successes, the Standard Model has limitations and leaves several questions unanswered. Physicists are exploring theories and phenomena beyond the Standard Model, including:

1. Dark Matter and Dark Energy: *Observations suggest that ordinary matter constitutes only about 5% of the universe, while dark matter and dark energy make up the remaining 95%. Understanding the nature of these mysterious components is a major focus of current research.*

2. Supersymmetry: *This theoretical framework proposes that every particle in the Standard Model has a corresponding superpartner with different spin properties. Supersymmetry aims to address some of the limitations of the Standard Model and provide a pathway to unifying fundamental forces.*

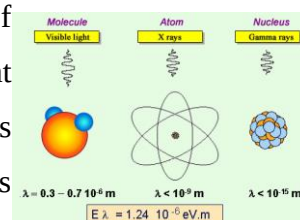
3. String Theory: *This theoretical framework suggests that fundamental particles are not point-like, but rather one-dimensional "strings" that vibrate at different frequencies. String theory seeks to unify all fundamental forces, including gravity, into a single coherent framework.*



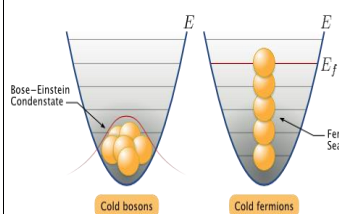
Particle physics is a field that continues to push the boundaries of human knowledge and explore the fundamental nature of reality. By studying the smallest constituents of matter and their interactions, physicists aim to answer profound questions about the universe's origin, structure, and underlying principles. As research progresses and new discoveries are made, the fascinating world of particle physics promises to reveal even deeper insights into the mysteries of the space.

NOTES

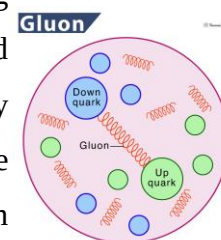
1. **Photons** are the elementary particles that serve as the quantum carriers of the electromagnetic force. They are massless and travel at the speed of light in a vacuum, embodying the dual nature of both particles and waves. This duality allows photons to exhibit properties of classical waves, such as interference and diffraction, as well as particle-like behaviors, such as the photoelectric effect, where they can knock electrons out of atoms. As mediators of electromagnetic interactions, photons play a crucial role in phenomena ranging from the transmission of light and radio waves to the binding of electrons within atoms.



2. **Bosons** are a category of fundamental particles characterized by their integer spin, as opposed to fermions, which have half-integer spin. They are responsible for mediating the fundamental forces of nature. Unlike fermions, bosons can occupy the same quantum state simultaneously, a property that leads to phenomena like the condensation of particles in Bose-Einstein condensates. Notable examples of bosons include photons, which mediate the electromagnetic force; W and Z bosons, which mediate the weak nuclear force; gluons, which mediate the strong nuclear force; and the Higgs boson, which is associated with the Higgs field that imparts mass to other particles.



3. **Gluons** are the elementary particles responsible for mediating the strong nuclear force, which is the force that holds quarks together to form protons and neutrons. These force carriers are themselves massless and possess a property known as color charge, which they exchange between quarks to maintain the integrity of atomic nuclei. Gluons operate within the framework of quantum chromodynamics (QCD), a theory that describes the interactions between quarks and gluons. Their ability to bind quarks together is crucial for the stability of matter, preventing protons and neutrons from disintegrating and allowing for the existence of the atomic nucleus.



b) Translate the italicized paragraphs into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

2. Synonym Groups for Physics Vocabulary:

Select 5 key terms from the text. For each term, create a list of 2 to 6 synonyms that capture the same or similar meanings within the context of physics. Below are examples to learn and to guide you.

- 1. Fundamental particles** - Elementary particles - Basic particles - Primary particles - Indivisible particles
- 2. Fermions** - Matter particles - Subatomic particles - Quark-lepton particles - Building block particles
- 3. Bosons** - Force carriers - Mediator particles - Interaction particles - Gauge particles
- 4. Electromagnetic Force** - Electric force - Magnetic force - Electromagnetic interaction - EM force
- 5. Weak Nuclear Force** - Weak interaction - Weak force - Beta decay force - W and Z boson force
- 6. Strong Nuclear Force** - Strong interaction - Strong force - Nuclear binding force - Gluon force
- 7. Particle Accelerators** - Particle colliders - Particle smashers - High-energy accelerators - Atom smashers
- 8. Standard Model** - Particle physics model - Fundamental interaction model - Elementary particle framework - Subatomic particle theory
- 9. Dark Matter** - Invisible matter - Non-luminous matter - Hidden mass - Unknown matter
- 10. Supersymmetry** — SUSY - Symmetrical particles - Supersymmetric theory - Symmetry model

3. Using the dictionary transcribe and translate the key words:

Word	Transcription	Translation
fermions		

bosons		
electromagnetic force		
nuclear force		
particle accelerators		
Large Hadron Collider		
supersymmetry		
bind		
mediates		
accelerate		
subatomic		
hypothetical		
mysterious		
coherent		
leptons		

4. Match the words with their definition:

Fermions	A fundamental particle associated with the Higgs field, which gives mass to other particles. The discovery of the Higgs boson at the Large Hadron Collider in 2012 confirmed its existence.
Bosons	Particles that make up matter, including quarks and leptons. They follow the Pauli exclusion principle, which states that no two identical fermions can occupy the same quantum state simultaneously.

Quarks	A fundamental force mediated by gluons, responsible for binding quarks together to form protons and neutrons, and for holding protons and neutrons together within atomic nuclei.
Dark matter	Elementary particles that combine to form protons and neutrons. There are six types (or "flavors") of quarks: up, down, charm, strange, top, and bottom.
Leptons	A fundamental force mediated by W and Z bosons, responsible for processes such as beta decay in radioactive atoms. It plays a key role in nuclear reactions and element synthesis in stars.
Higgs boson	A form of matter that does not emit or interact with electromagnetic radiation, making it invisible to current detection methods. It is believed to constitute a significant portion of the universe's total mass.
Strong nuclear force	Particles that mediate the fundamental forces of nature. Unlike fermions, bosons can occupy the same quantum state, and they include particles such as photons, W and Z bosons, gluons, and the Higgs boson.
Electromagnetic force	Machines that accelerate charged particles to high speeds and collide them to study fundamental interactions and particles. Examples include the Large Hadron Collider (LHC) and Tevatron.
Weak nuclear force	A fundamental force mediated by photons, responsible for interactions between charged particles. It governs phenomena such as electricity, magnetism, and light.

Particle accelerators	A family of elementary particles that include electrons, muons, tau particles, and their corresponding neutrinos. Leptons do not participate in strong nuclear interactions.
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5. Give English equivalents to the meanings of the following words and word combinations:

елементарні частинки	
теоретична основа	
прискорювач частинок	
фізичні процеси	
взаємодія матерії	
фундаментальні сили природи	
гравітаційна сила	
електромагнітні явища	
загальна теорія відносності	
електромагнітне випромінювання	
квантова механіка	
експериментальні відкриття	

6. Find synonyms to the words:

1. Interactions -
2. Govern -
3. Particles -
4. Forces -

- 5. Accelerate -
- 6. Observe -
- 7. Mysterious -
- 8. Detection -
- 9. Decay -
- 10. Hypothetical -

7. Choose the correct answer:

1. What are fermions responsible for?
 - A) Mediating fundamental forces
 - B) Making up matter
 - C) Emitting electromagnetic radiation
 - D) Forming dark matter
2. Which particles mediate the strong nuclear force?
 - A) Photons
 - B) W and Z bosons
 - C) Gluons
 - D) Gravitons
3. What discovery confirmed the existence of the Higgs field?
 - A) Discovery of dark matter
 - B) Detection of the Higgs boson
 - C) Observation of neutrinos
 - D) Identification of quarks
4. What is the primary focus of the Standard Model of particle physics?
 - A) Describing gravity
 - B) Explaining the fundamental particles and their interactions
 - C) Understanding dark matter and dark energy
 - D) Analyzing large-scale cosmic structures

5. Which fundamental force is not included in the Standard Model?
- A) Electromagnetic force
 - B) Weak nuclear force
 - C) Strong nuclear force
 - D) Gravitational force
6. What is the main purpose of particle accelerators?
- A) To observe celestial bodies
 - B) To accelerate particles to high speeds and study their interactions
 - C) To detect gravitational waves
 - D) To measure the temperature of the Earth's core
7. Which theoretical framework suggests that every particle has a corresponding superpartner?
- A) String Theory
 - B) General Relativity
 - C) Supersymmetry
 - D) Quantum Electrodynamics
8. What percentage of the universe is believed to be composed of dark matter and dark energy?
- A) 5%
 - B) 20%
 - C) 50%
 - D) 95%
9. Which is the best way to translate the following sentence:
- Quarks combine to form protons and neutrons, which are the building blocks of atomic nuclei.*
- A) Кварки комбінуються, щоб утворити протони і нейтрони, які є будівельними блоками атомних ядер.

В) Кварки об'єднуються, щоб утворити електрони і фотони, що є основою світлових явищ.

С) Кварки поєднуються для створення атомів і молекул, що складають матерію.

Д) Кварки з'єднуються, щоб утворити частинки темної матерії у всесвіті.

10. Which is the best way to translate the following sentence:

The discovery of the Higgs boson at the Large Hadron Collider confirmed the existence of the Higgs field.

А) Відкриття бозона Хіггса на Великому адронному колайдері підтвердило існування поля Хіггса.

В) Відкриття частинок темної матерії на Великому адронному колайдері підтвердило існування темної енергії.

С) Виявлення нейтронів на прискорювачі частинок підтвердило існування поля нейтрино.

Д) Відкриття бозона Хіггса на прискорювачі частинок в США підтвердило існування бозона фотона.

8. Translate the following sentences into Ukrainian:

1. The Large Hadron Collider (LHC) is the world's most powerful particle accelerator, capable of accelerating particles to near-light speeds to study their interactions.

2. Neutrinos are nearly massless subatomic particles that rarely interact with matter, making them extremely difficult to detect.

3. Supersymmetry proposes that each particle in the Standard Model has a corresponding superpartner with different spin properties.

4. String theory suggests that the fundamental constituents of the universe are not point particles, but rather one-dimensional "strings" that vibrate at different frequencies.

5. Dark matter is believed to constitute approximately 27% of the universe, influencing the formation and behavior of galaxies through its gravitational effects.

9. Translate the following sentences into English:

1. Великі адронні колайдери дозволяють дослідникам детально вивчати фундаментальні взаємодії між субатомними частинками.

2. Темна матерія залишається однією з найбільших загадок сучасної фізики, оскільки її неможливо безпосередньо спостерігати.

3. Ферміони й бозони є двома основними класами елементарних частинок, що мають різні квантові властивості.

4. Стандартна модель фізики частинок успішно пояснює більшість спостережуваних явищ, але все ще не включає гравітаційну взаємодію.

5. Суперсиметрія є теоретичною концепцією, яка припускає існування партнерів для кожної відомої елементарної частинки.

10. Answer the questions to the text

1. What are the two main categories of fundamental particles in the Standard Model of particle physics

2. How are fermions categorized, and what particles belong to each category?

3. Which particles are responsible for mediating interactions, and what are they called in particle physics?

4. What role does the electromagnetic force play, and which boson mediates it?

5. What is the weak nuclear force, and which processes does it govern?

6. What function does the strong nuclear force serve, and which particles mediate it?

7. What is the Large Hadron Collider, and what discovery confirmed the existence of the Higgs field?

8. What are the limitations of the Standard Model, and which fundamental force is not included in it?

9. What is supersymmetry, and which issues in the Standard Model does it attempt to address?

10. What role does dark matter play in the universe, and how does it influence the formation of galaxies?

11. Write a short summary of the text (See the scheme in the Information File – ex. 11 p. 16) and be ready to present it.

S P E A K I N G

1. Guidelines for Discussion:

1. Exploring Fundamental Particles:

Discuss the distinction between fermions and bosons. What are their roles in the Standard Model, and how do they contribute to the structure and behavior of matter? Consider the implications of quarks and leptons as the building blocks of matter.

2. Understanding Fundamental Forces:

Analyze the four fundamental forces: gravitational, electromagnetic, weak nuclear, and strong nuclear forces. How do these forces interact with particles, and what are their specific roles in the universe? Delve into the mediating particles (bosons) for each force and their significance.

The Standard Model and Its Limitations:

Evaluate the successes and limitations of the Standard Model of particle physics. What phenomena does it explain well, and what areas remain unresolved or incomplete? Consider the absence of gravity in the Standard Model and the quest for a unified theory.

Particle Accelerators and Discoveries:

Discuss the role of particle accelerators like the Large Hadron Collider (LHC) in advancing our understanding of particle physics. What key discoveries have been made using these accelerators, and how have they shaped our knowledge of fundamental particles and forces?

Beyond the Standard Model: Theories and Mysteries:

Explore theories and concepts beyond the Standard Model, such as supersymmetry, string theory, dark matter, and dark energy. How do these ideas aim to address the limitations of the Standard Model, and what are the potential implications for our understanding of the universe?

2. Translate the following text into English:

- a) Express the main idea of the text in one sentence;**
- b) Write a short summary of the text in English and present it.**

Фізика частинок: Заглиблення у фундаментальні складові Всесвіту

Фізика частинок - це галузь фізики, яка вивчає найменші складові Всесвіту та сили, які керують їх взаємодіями. Фундаментальні частинки, такі як кварки і лептони, є основою всіх матеріальних об'єктів. Кварки утворюють протони і нейтрони, а лептони включають електрони, мюони, тау-частинки та нейтрино. Ці частинки взаємодіють одна з одною за допомогою чотирьох фундаментальних сил: гравітаційної, електромагнітної, слабкої ядерної та сильної ядерної.

Стандартна модель фізики частинок - це теоретична основа, яка описує поведінку цих фундаментальних частинок і їх взаємодій. Вона успішно пояснює три з чотирьох фундаментальних сил (виключаючи гравітацію) та підтверджена численними експериментами. Однак Стандартна модель має свої обмеження, наприклад, вона не включає темну матерію та темну енергію, які становлять більшість маси Всесвіту.

Прискорювачі частинок, такі як Великий адронний колайдер (БАК), відіграють ключову роль у вивченні фізики частинок. БАК дозволяє прискорювати частинки до надзвичайно високих швидкостей та зіштовхувати їх, що дозволяє спостерігати за результатами цих взаємодій. Одним з найвизначніших відкриттів за допомогою БАК стало підтвердження існування бозона Хіггса, що підтвердило існування поля Хіггса, яке відповідає за масу частинок.

Попри успіхи Стандартної моделі, фізики продовжують шукати теорії, що виходять за її межі. Суперсиметрія, теорія струн та дослідження темної матерії є основними напрямками сучасних досліджень у фізиці частинок. Ці теорії мають потенціал вирішити існуючі проблеми та дати відповіді на питання, які залишаються відкритими, наближаючи нас до розуміння фундаментальної структури Всесвіту.

EXTENDED READING*

1.1* Read and translate the following texts Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Text 1

Key Components of the Standard Model

The Standard Model of particle physics is a theoretical framework that describes the fundamental particles and their interactions, providing a comprehensive understanding of the building blocks of the universe. This model has been remarkably successful in explaining the behavior of subatomic particles and has been validated

through numerous experiments. The key components of the Standard Model can be categorized into particles, forces, and interactions.

The Standard Model classifies fundamental particles into two main groups: fermions and bosons.

Fermions: These particles are the constituents of matter. Fermions are further divided into two subcategories: quarks and leptons.

Quarks: There are six types (or flavors) of quarks: up, down, charm, strange, top, and bottom. Quarks combine to form protons and neutrons, which are the building blocks of atomic nuclei.

Leptons: There are six types of leptons, including electrons, muons, tau particles, and their corresponding neutrinos. Leptons do not participate in strong nuclear interactions and are responsible for various fundamental processes.

Bosons: These particles are force carriers and mediate the fundamental forces of nature. There are several types of bosons, each associated with a specific force:

Photons: Mediate the electromagnetic force, which governs the interactions between charged particles.

W and Z bosons: Mediate the weak nuclear force, which is responsible for processes such as beta decay in radioactive atoms.

Gluons: Mediate the strong nuclear force, which binds quarks together to form protons and neutrons and holds these particles within atomic nuclei.

Higgs boson: Associated with the Higgs field, which gives mass to other particles. The discovery of the Higgs boson in 2012 at the Large Hadron Collider (LHC) confirmed its existence and its role in the Standard Model.

The Standard Model describes three of the four fundamental forces that govern particle interactions:

Electromagnetic Force: This force is mediated by photons and governs interactions between charged particles. It is responsible for phenomena such as electricity, magnetism, and light.

Weak Nuclear Force: Mediated by W and Z bosons, this force is responsible for processes such as beta decay and plays a crucial role in nuclear reactions and the synthesis of elements in stars.

Strong Nuclear Force: This force is mediated by gluons and is responsible for binding quarks together to form protons and neutrons. It also holds protons and neutrons together within atomic nuclei, ensuring the stability of matter.

The interactions between fundamental particles are governed by the exchange of force-carrying bosons. These interactions can be classified based on the forces involved:

Electromagnetic Interactions: Involving the exchange of photons between charged particles, these interactions are responsible for the behavior of atoms and molecules.

Weak Interactions: Involving the exchange of W and Z bosons, these interactions are essential for processes such as beta decay and neutrino interactions.

Strong Interactions: Involving the exchange of gluons, these interactions bind quarks together and hold atomic nuclei intact.

Higgs Mechanism: The interaction between particles and the Higgs field, mediated by the Higgs boson, provides particles with mass.

While the Standard Model has been highly successful, it has certain limitations. For example, it does not include gravity, which is described by the theory of general relativity. Additionally, the Standard Model does not account for dark matter and dark energy, which constitute the majority of the universe's mass and energy. To address these gaps, physicists are exploring theories beyond the Standard Model, such as supersymmetry, string theory, and quantum gravity.

The Standard Model of particle physics provides a comprehensive framework for understanding the fundamental particles and forces that make up the universe. By classifying particles into fermions and bosons and describing their interactions through fundamental forces, the Standard Model has revolutionized our understanding of the subatomic world. As research continues, physicists aim to uncover new insights and

address the limitations of this model, further expanding our knowledge of the universe's fundamental nature.

1.2* Comprehension Questions:

1. What are the two main groups of fundamental particles in the Standard Model?
2. How are quarks categorized, and how many types of quarks are there?
3. Describe the role of bosons in the Standard Model and name the bosons associated with the fundamental forces.
4. Explain the electromagnetic force and its mediating particle.
5. What processes are governed by the weak nuclear force, and which particles mediate it?
6. How does the strong nuclear force contribute to the stability of matter, and which particles mediate this force?
7. What is the significance of the Higgs boson in the Standard Model?
8. What are the limitations of the Standard Model, and which fundamental force is not included in it?
9. How do particle accelerators contribute to our understanding of particle physics?
10. What are some theories and concepts being explored beyond the Standard Model?

1.3* Vocabulary and Terminology:

a) Define the following terms	b) Match the terms to their definitions
1. Fermions	a) Force carriers that mediate the fundamental forces of nature.
2. Bosons	b) Particles that are the constituents of matter.
3. Quarks	c) Elementary particles that combine to form protons and neutrons.

4. Leptons	d) A family of particles including electrons and neutrinos.
5. Higgs boson	e) The particle associated with the Higgs field, responsible for giving mass to other particles.

1.4* Write a brief summary of the text in your own words in 5-6 sentences.

1.5* Discussion Prompts:

1. Discuss the significance of quarks and leptons as the building blocks of matter. How do their interactions shape the structure of the universe?
2. Explore the role of the Higgs boson and the Higgs field in the Standard Model. How did the discovery of the Higgs boson impact our understanding of particle physics?
3. Reflect on the importance of particle accelerators like the Large Hadron Collider in advancing particle physics. What key discoveries have been made using these machines?
4. Analyze the limitations of the Standard Model. What are the challenges faced by physicists in developing a unified theory that includes gravity?
5. Discuss the potential implications of theories beyond the Standard Model, such as supersymmetry and string theory. How might these theories address the unanswered questions in particle physics?

1.6* Research and Presentation:

1. Conduct research on the six types of quarks and their properties. Prepare a presentation detailing their characteristics, interactions, and roles in forming protons and neutrons.
2. Explore the role of interdisciplinary collaboration in particle physics research. Identify how physicists, engineers, and computer scientists work together to conduct

experiments and analyze data at facilities like CERN. Present your findings and discuss the importance of such collaboration.

Text 2

2.1* Read and translate the following texts Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Quantum Gravity: Bridging Quantum Mechanics and General Relativity

Quantum gravity is a field of theoretical physics that aims to unify the principles of quantum mechanics with general relativity to describe the fundamental nature of gravity at the quantum scale. This ambitious endeavor seeks to reconcile the two pillars of modern physics: Einstein's theory of general relativity, which describes gravity as the curvature of spacetime caused by mass and energy, and quantum mechanics, which governs the behavior of particles at the smallest scales. Despite their individual successes, these theories are fundamentally incompatible in their current forms, necessitating a new framework to fully understand the quantum aspects of gravity.

The Challenges of Unification. One of the major challenges in developing a theory of quantum gravity is the incompatibility between general relativity and quantum mechanics. General relativity operates on a classical level, describing the smooth, continuous fabric of spacetime, whereas quantum mechanics deals with discrete particles and probabilistic events. At the Planck scale, where the effects of both quantum mechanics and gravity become significant, the classical description of spacetime breaks down, requiring a quantum theory of gravity.

Approaches to Quantum Gravity. Several theoretical approaches have been proposed to tackle the problem of quantum gravity. Some of the most prominent include:

String Theory: One of the most well-known attempts to unify quantum mechanics and gravity, string theory posits that fundamental particles are not point-like objects but rather one-dimensional "strings" that vibrate at different frequencies. These vibrations correspond to different particles, and the interactions between strings can potentially describe all fundamental forces, including gravity.

Loop Quantum Gravity (LQG): Loop quantum gravity is an approach that attempts to quantize spacetime itself. It suggests that spacetime is composed of discrete loops or networks of quantum states, known as spin networks. LQG aims to provide a background-independent description of quantum gravity, meaning it does not rely on a predefined spacetime structure.

Causal Dynamical Triangulations (CDT): This approach uses a method called triangulation to model the quantum properties of spacetime. CDT breaks down spacetime into smaller, discrete units called simplices and studies how they interact and evolve. This method aims to preserve the causal structure of spacetime while incorporating quantum effects.

Holographic Principle: Inspired by black hole thermodynamics, the holographic principle suggests that the information describing a volume of space can be encoded on its boundary. This idea has led to the development of the AdS/CFT correspondence, which proposes a relationship between a gravity theory in a higher-dimensional "bulk" space and a lower-dimensional quantum field theory on the boundary.

Experimental Challenges. One of the significant obstacles in the study of quantum gravity is the lack of experimental evidence. The effects of quantum gravity are expected to be significant only at extremely small scales, such as the Planck length (approximately 1.616×10^{-35} meters), making direct observation or experimentation currently beyond our technological capabilities. As a result, most research in quantum gravity remains highly theoretical.

Implications and Future Prospects. A successful theory of quantum gravity would have profound implications for our understanding of the universe. It could

potentially resolve singularities, such as those found at the centers of black holes or the Big Bang, where classical general relativity breaks down. Additionally, it could provide insights into the nature of spacetime, the origin of the universe, and the fundamental structure of reality.

The quest for a theory of quantum gravity continues to be one of the most exciting and challenging endeavors in theoretical physics. As researchers explore new ideas and develop innovative mathematical frameworks, the potential for groundbreaking discoveries remains high. The unification of quantum mechanics and general relativity promises to revolutionize our understanding of the cosmos and unlock new realms of knowledge about the universe's deepest mysteries.

2.2* Comprehension Questions:

1. What is the main goal of quantum gravity in theoretical physics?
2. Why are general relativity and quantum mechanics considered incompatible at the quantum scale?
3. Describe the primary idea behind string theory and how it attempts to unify quantum mechanics and gravity.
4. What is loop quantum gravity (LQG) and how does it conceptualize spacetime?
5. Explain the approach of causal dynamical triangulations (CDT) in studying quantum properties of spacetime.
6. What is the holographic principle, and how does it relate to the AdS/CFT correspondence?
7. Why is experimental evidence for quantum gravity currently challenging to obtain?
8. How could a successful theory of quantum gravity impact our understanding of singularities, such as those in black holes or the Big Bang?
9. What are some potential implications of a unified theory of quantum gravity for our understanding of the universe?

2.3* Vocabulary and Terminology:

Define the following terms	Match the terms to their definitions
1. Quantum gravity	a) A theory proposing that fundamental particles are one-dimensional "strings" that vibrate at different frequencies.
2. General relativity	b) The theory describing gravity as the curvature of spacetime caused by mass and energy.
3. Quantum mechanics	c) The branch of physics governing the behavior of particles at the smallest scales.
4. String theory	d) The idea that the information describing a volume of space can be encoded on its boundary.
5. Holographic principle	e) A field of theoretical physics aiming to unify quantum mechanics with general relativity.

2.4* Summarize the text in your own words in 5-6 sentences.

2.5* Discussion Prompts:

1. Discuss the significance of reconciling general relativity with quantum mechanics. How would a unified theory of quantum gravity advance our understanding of fundamental physics?

2. Explore the various approaches to quantum gravity, such as string theory, loop quantum gravity, and causal dynamical triangulations. What are the strengths and limitations of each approach?

3. Reflect on the challenges of obtaining experimental evidence for quantum gravity. What technological advancements or discoveries might help overcome these challenges?

4. Analyze the potential implications of the holographic principle for our understanding of spacetime and information theory. How does the AdS/CFT correspondence contribute to this understanding?

5. Debate the philosophical and scientific implications of a successful theory of quantum gravity. How might it change our perception of the universe and our place within it?

2.6* Research and Presentation:

1. Conduct research on the Planck scale and its significance in quantum gravity. Prepare a presentation detailing the key concepts, including the Planck length, Planck time, and Planck energy.

2. Explore the role of interdisciplinary collaboration in quantum gravity research. Identify how physicists, mathematicians, and computer scientists work together to develop theoretical models and conduct simulations. Present your findings and discuss the importance of such collaboration.

UNIT XII

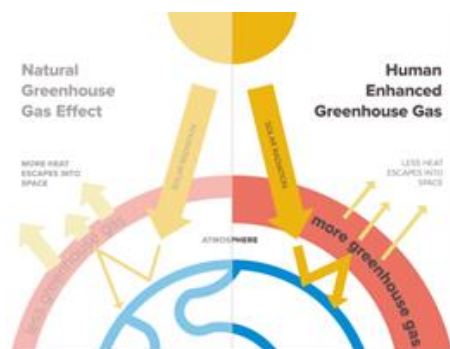
CLIMATE CHANGE AND GLOBAL WARMING

TEXT

Understanding Climate Change and Global Warming: A Physics Perspective

1. a) Read and translate the text using the dictionary:

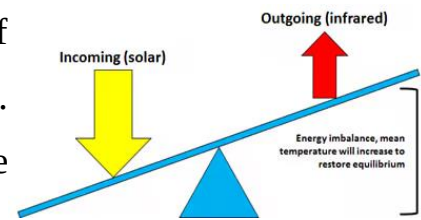
Climate change and global warming are critical issues facing our planet today, and their understanding is deeply rooted in the principles of physics. These phenomena result from complex interactions between the Earth's atmosphere, oceans, and land, driven by physical processes that govern the behavior of gases, radiation, and energy.



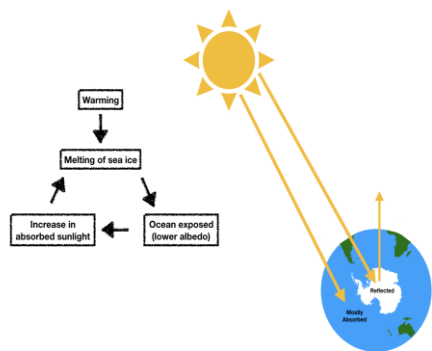
The Greenhouse Effect. At the heart of global warming lies the greenhouse effect, a fundamental concept in atmospheric physics. The Earth's atmosphere contains greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and water vapor (H_2O). These gases are capable of absorbing and re-emitting infrared radiation, which is a form of thermal radiation.

When solar radiation reaches the Earth, it is absorbed by the surface and re-emitted as infrared radiation. Greenhouse gases trap some of this infrared radiation, preventing it from escaping back into space. This process warms the atmosphere and the surface of the Earth, much like a greenhouse traps heat to nurture plants. While the greenhouse effect is a natural and necessary phenomenon that keeps our planet habitable, the excessive increase in greenhouse gases due to human activities has intensified this effect, leading to global warming.

Energy Balance and Radiative Forcing. The concept of energy balance is crucial in understanding climate change. The Earth's climate system is in a delicate equilibrium, where the energy received from the Sun is balanced by the energy radiated back into space. Any imbalance in this energy budget can lead to changes in the climate.

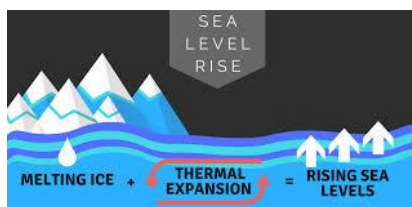
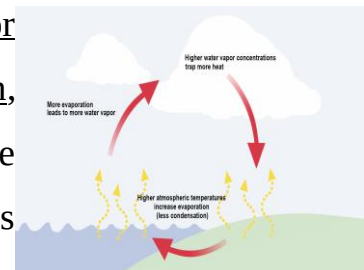


Radiative forcing is a measure of the change in energy balance caused by factors such as greenhouse gas emissions, aerosols, and changes in solar radiation. Positive radiative forcing, primarily driven by increased greenhouse gas concentrations, leads to warming, while negative radiative forcing, influenced by factors like volcanic eruptions and aerosols, can cause cooling. The net effect of these forces determines the overall change in the Earth's climate.



Feedback Mechanisms. Climate change involves various feedback mechanisms that can amplify or dampen the effects of warming. One significant feedback mechanism is the ice-albedo feedback. Ice and snow have high albedo, meaning they reflect a large portion of incoming solar radiation. As global temperatures rise, ice and snow melt, reducing the Earth's albedo and causing more solar radiation to be absorbed by the surface, further warming the planet.

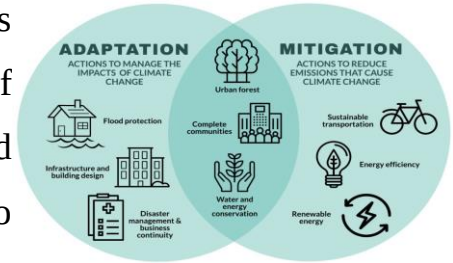
Another critical feedback mechanism is the water vapor feedback. Warmer temperatures increase the rate of evaporation, leading to higher concentrations of water vapor in the atmosphere. Since water vapor is a potent greenhouse gas, this enhances the greenhouse effect and accelerates warming.



Thermal Expansion and Sea-Level Rise. Physics also explains the phenomenon of sea-level rise, a direct

consequence of global warming. As the Earth's temperature increases, the oceans absorb much of this heat, causing the water to expand—a process known as thermal expansion. Additionally, the melting of glaciers and polar ice caps adds more water to the oceans. Both thermal expansion and the influx of meltwater contribute to rising sea levels, posing significant risks to coastal communities and ecosystems.

Mitigation and Adaptation. Addressing climate change requires a combination of mitigation and adaptation strategies. Mitigation involves reducing greenhouse gas emissions through the adoption of renewable energy sources, energy efficiency, and sustainable practices. Adaptation focuses on adjusting to the impacts of climate change, such as building resilient infrastructure, protecting natural ecosystems, and preparing for extreme weather events.



Understanding climate change and global warming from a physics perspective provides valuable insights into the processes driving these phenomena. By applying the principles of atmospheric physics, energy balance, and feedback mechanisms, scientists can better predict and address the impacts of climate change. As we strive to mitigate and adapt to these challenges, a thorough understanding of the underlying physical principles is essential for developing effective solutions and ensuring a sustainable future for our planet.

b) Translate the italicized paragraphs into Ukrainian (in writing).

c) Translate the underlined words and word combinations into Ukrainian (in writing).

d) Put 5 questions to the text.

2. Synonym Groups for Physics Vocabulary:

Select 5 key terms from the text. For each term, create a list of 2 to 6 synonyms that capture the same or similar meanings within the context of physics. Below are examples to learn and to guide you.

1. **Greenhouse effect** - Thermal radiation trapping - Heat retention - Atmospheric warming - Greenhouse phenomenon
2. **Radiative forcing** - Energy imbalance - Radiation impact - Climatic forcing - Radiative influence
3. **Feedback mechanisms** - Feedback loops - Climatic feedbacks - Regulatory mechanisms - Response systems
4. **Thermal expansion** - Heat-induced expansion - Temperature-driven expansion - Thermal growth - Expansion due to heating
5. **Sea-level rise** - Ocean level increase - Rising sea levels - Coastal flooding - Oceanic elevation
6. **Mitigation** - Reduction — Alleviation — Diminishment – Abatement
7. **Adaptation** - Adjustment — Acclimatization — Modification – Adaptability
8. **Greenhouse gases** - Heat-trapping gases - Climatic gases - Atmospheric gases - Warming gases
9. **Energy balance** - Energy equilibrium - Energy budget - Thermal balance - Heat distribution
10. **Global warming** - Climate heating - Planetary warming - Global temperature rise - Climatic warming

3. Using the dictionary transcribe and translate the key words:

Word	Transcription	Translation
Greenhouse effect		
Infrared radiation		

Atmosphere		
Global warming		
Climate change		
Carbon dioxide		
Methane		
Water vapor		
Radiative forcing		
Energy balance		
Albedo		
Sea-level rise		
Thermal expansion		
Mitigation		
Adaptation		

4. Match the words with their definition:

1. Greenhouse effect	a) A measure of the influence of a factor (such as greenhouse gases) on the balance of incoming and outgoing energy in the Earth's climate system; typically measured in watts per square meter.
2. Infrared radiation	b) The increase in volume of a substance (such as water) due to an increase in temperature, which contributes to sea-level rise in the context of climate change.

3. Atmosphere	c) Efforts and actions taken to reduce or prevent the emission of greenhouse gases, aiming to limit the magnitude or rate of long-term climate change.
4. Radiative forcing	d) A type of electromagnetic radiation with wavelengths longer than visible light but shorter than microwave radiation; it is emitted by objects based on their temperature.
5. Carbon dioxide	e) The increase in the average level of the world's oceans, primarily caused by thermal expansion of seawater and melting of ice from glaciers and ice caps.
6. Feedback mechanisms	f) The layer of gases surrounding the Earth or another planet, held in place by gravity, and composed primarily of nitrogen, oxygen, and trace gases.
7. Thermal expansion	g) The process of adjusting to actual or expected climate change and its effects, in order to reduce harm or exploit beneficial opportunities.
8. Sea-level rise	h) A colorless, odorless gas (CO ₂) produced by burning carbon-based fuels, respiration, and other processes; it is a significant greenhouse gas contributing to global warming.
9. Mitigation	i) Processes that can either amplify (positive feedback) or diminish (negative feedback) the effects of climate change by interacting with various components of the climate system.

10. Adaptation	j) The process by which certain gases in the Earth's atmosphere trap infrared radiation, leading to the warming of the Earth's surface and lower atmosphere.
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5. Give English equivalents to the meanings of the following words and word combinations:

Прогнозувати	
Посилювати	
Випромінювати	
Поглинати	
Стійкі практики	
Відновлювальні джерела енергії	
Екстремальні погодні явища	
Прибережні зони	
Танення льодовиків	
Глобальні температури	
Первинні фактори	
Кліматична система	
Проміжок часу	
Атмосферні процеси	
Земна поверхня	
Теплове випромінювання	
Парникові гази	

6. Find synonyms to the words:

Influence -

Expansion -

Emissions -

Sustainable -

Contribute -

Significant -

Increase -

Atmosphere -

Mitigate -

Concentration -

7. Choose the correct answer:

1. What is the primary driver of the greenhouse effect?

- A) Ozone layer depletion
- B) Greenhouse gas emissions
- C) Volcanic eruptions
- D) Solar radiation

2. Which of the following gases is NOT considered a greenhouse gas?

- A) Carbon dioxide (CO₂)
- B) Methane (CH₄)
- C) Oxygen (O₂)
- D) Water vapor (H₂O)

3. What is radiative forcing?

- A) The force exerted by the Earth's magnetic field
- B) The measure of the change in energy balance caused by factors such as greenhouse gases
- C) The impact of gravity on atmospheric pressure

D) The reflection of solar radiation by the Earth's surface

4. What is the effect of thermal expansion on sea levels?

A) Decreases sea levels

B) Has no impact on sea levels

C) Increases sea levels

D) Stabilizes sea levels

5. Which feedback mechanism is associated with the melting of ice and snow?

A) Water vapor feedback

B) Ice-albedo feedback

C) Carbon feedback

D) Ocean-atmosphere feedback

6. What is the primary goal of mitigation in the context of climate change?

A) Increasing greenhouse gas emissions

B) Reducing greenhouse gas emissions

C) Monitoring weather patterns

D) Studying ocean currents

7. How does dark matter influence the structure of the cosmic web?

A) By emitting visible light

B) Through its gravitational forces

C) By blocking solar radiation

D) Through chemical reactions

8. What role does adaptation play in addressing climate change?

A) Reducing the amount of solar radiation reaching Earth

B) Adjusting to the impacts of climate change

C) Eliminating all greenhouse gases

D) Increasing the Earth's albedo

9. Which is the best way to translate the following sentence:

Thermal expansion is a major factor contributing to sea-level rise.

- A) Теплове розширення є основним фактором, що сприяє підвищенню рівня моря.
- B) Температурне розширення є основною причиною підвищення температури Землі.
- C) Теплове випромінювання сприяє збільшенню площі льодовиків.
- D) Тепловий вплив є важливим фактором зміни клімату.

10. Which is the best way to translate the following sentence:

Mitigation involves reducing greenhouse gas emissions to limit global warming

- A) Міграція включає зменшення викидів парникових газів для обмеження глобального потепління.
- B) Міграція включає зміни у використанні землі для зменшення глобального потепління.
- C) Пом'якшення включає зменшення викидів парникових газів для обмеження глобального потепління.
- D) Пом'якшення включає підвищення викидів для регулювання глобального потепління.

8. Translate the following sentences into Ukrainian:

1. The increased emissions of carbon dioxide and methane are key drivers behind the intensification of the greenhouse effect.
2. Radiative forcing plays a crucial role in determining the balance between incoming solar radiation and outgoing infrared radiation in the Earth's climate system.
3. Thermal expansion of seawater, combined with the melting of polar ice caps, contributes significantly to the ongoing rise in sea levels.
4. Effective mitigation strategies, such as transitioning to renewable energy sources and enhancing energy efficiency, are essential to combat global warming.
5. Understanding the feedback mechanisms within the climate system, such as the ice-albedo effect, is vital for predicting future climate changes.

9. Translate the following sentences into English:

1. Парникові гази, такі як метан і вуглекислий газ, значно посилюють ефект глобального потепління.

2. Радіаційний вплив є важливим чинником у визначенні енергетичного балансу кліматичної системи Землі.

3. Теплове розширення океанів, поряд із таненням льодовиків, суттєво впливає на підвищення рівня моря.

4. Ефективні стратегії пом'якшення, такі як перехід на відновлювальні джерела енергії, мають вирішальне значення для боротьби з глобальним потеплінням.

5. Розуміння механізмів зворотного зв'язку в кліматичній системі, наприклад, ефекту альбедо, є ключовим для прогнозування майбутніх змін клімату.

10. Answer the questions to the text:

1. What is the greenhouse effect, and how does it contribute to global warming?

2. Which greenhouse gases are primarily responsible for the intensification of the greenhouse effect?

3. How does radiative forcing influence the energy balance of the Earth's climate system?

4. What role does thermal expansion play in sea-level rise, and what other factors contribute to this phenomenon?

5. How does the ice-albedo feedback mechanism amplify the effects of global warming?

6. What are some effective mitigation strategies to reduce greenhouse gas emissions?

7. What is the significance of understanding feedback mechanisms within the climate system?

8. How do human activities impact the concentration of greenhouse gases in the atmosphere?

9. What are the potential consequences of rising sea levels for coastal communities and ecosystems?

10. Why is it essential to understand the physical principles behind climate change for developing effective solutions?

11. Write a short summary of the text (See the scheme in the Information File – ex.11 p. 16) and be ready to present it.

S P E A K I N G

1. Guidelines for Discussion:

1. Exploring the Greenhouse Effect:

Discuss the fundamental principles of the greenhouse effect, including the role of greenhouse gases in trapping infrared radiation. How does this process contribute to global warming, and what are the primary sources of these gases?

2. Impact of Radiative Forcing:

Analyze the concept of radiative forcing and its significance in the Earth's energy balance. What factors contribute to positive and negative radiative forcing, and how do they influence climate change?

3. Thermal Expansion and Sea-Level Rise:

Examine the relationship between thermal expansion and sea-level rise. How does the warming of ocean waters lead to expansion, and what are the additional factors contributing to rising sea levels? Discuss the potential impacts on coastal communities and ecosystems.

4. Mitigation Strategies:

Discuss various mitigation strategies to reduce greenhouse gas emissions and combat global warming. What are the roles of renewable energy sources, energy

efficiency, and sustainable practices in these efforts? Evaluate the effectiveness of these strategies and potential challenges in their implementation.

5. Understanding Feedback Mechanisms:

Explore the different feedback mechanisms within the climate system, such as the ice-albedo feedback and water vapor feedback. How do these mechanisms amplify or dampen the effects of climate change? Discuss the importance of understanding these feedbacks for accurate climate modeling and prediction.

2. Translate the following text into English:

- a) Express the main idea of the text in one sentence;**
- b) Write a short summary of the text in English and present it.**

Зміна клімату та глобальне потепління: Фізичні аспекти

Зміна клімату та глобальне потепління є серйозними викликами для нашої планети, і їх розуміння базується на принципах фізики. Основним рушійним фактором глобального потепління є парниковий ефект, який виникає через збільшення концентрації парникових газів у атмосфері Землі. Ці гази, такі як вуглекислий газ (CO_2), метан (CH_4) та водяна пара (H_2O), поглинають і випромінюють інфрачервоне випромінювання, яке надходить від поверхні Землі. Це спричиняє нагрівання атмосфери і поверхні планети, подібно до того, як парник утримує тепло для рослин.

Енергетичний баланс є ключовим поняттям у розумінні зміни клімату. Земна кліматична система підтримує делікатну рівновагу між енергією, яка надходить від Сонця, та енергією, яка випромінюється назад у космос. Будь-який дисбаланс у цьому енергетичному бюджеті може призвести до змін клімату. Радіаційний вплив, який вимірює зміну енергетичного балансу, спричинену факторами, такими як

викиди парникових газів і аерозолів, відіграє важливу роль у визначенні ступеня потепління або охолодження клімату.

Механізми зворотного зв'язку також відіграють значну роль у зміні клімату. Один з таких механізмів - це ефект альbedo льоду. Лід та сніг мають високе альbedo, тобто вони відбивають велику частину сонячного випромінювання. З підвищенням температури лід та сніг тануть, знижуючи альbedo Землі і спричиняючи збільшення поглинання сонячного випромінювання, що ще більше нагріває планету. Інший важливий механізм - це зворотний зв'язок з водяною парою: з підвищенням температури більше води випаровується, збільшуючи концентрацію водяної пари в атмосфері, що посилює парниковий ефект.

Таким чином, розуміння фізичних процесів, що лежать в основі зміни клімату та глобального потепління, є надзвичайно важливим для розробки ефективних заходів щодо зменшення викидів парникових газів і адаптації до змін клімату. Використання відновлюваних джерел енергії, підвищення енергоефективності та впровадження стійких практик є ключовими кроками у боротьбі з глобальним потеплінням та забезпеченні сталого майбутнього для нашої планети.

EXTENDED READING *

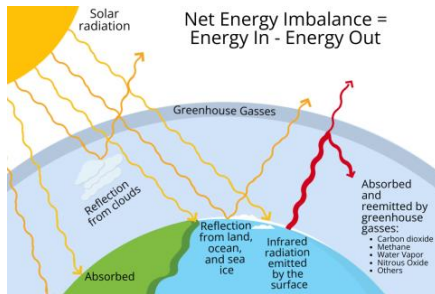
1.1* Read and translate the following texts Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

Text 1

Positive and Negative Radiative Forcing: Understanding Their Impact on Climate

Radiative forcing is a crucial concept in climate science that describes the influence of factors on the Earth's energy balance. It measures the change in energy flux

in the atmosphere due to natural and human-induced activities. Radiative forcing is typically quantified in watts per square meter (W/m^2), and it can be positive or negative, leading to warming or cooling effects, respectively.



Positive radiative forcing occurs when there is an increase in the net energy flux into the Earth's climate system, causing the planet to warm. This type of forcing can be driven by various factors, including:

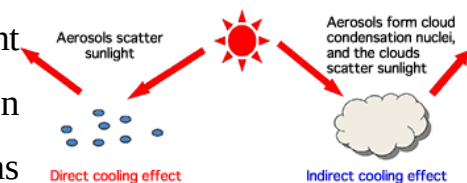
The primary contributors to positive radiative forcing are greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These gases trap infrared radiation emitted by the Earth's surface, preventing it from escaping into space and thereby warming the atmosphere.

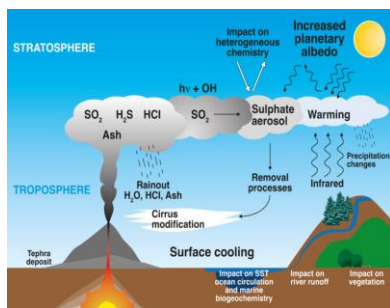
Certain aerosols, such as black carbon (soot), absorb sunlight and heat the atmosphere. These particles can settle on snow and ice, reducing their albedo (reflectivity) and causing additional warming by increasing the absorption of solar radiation.

Deforestation and urbanization can lead to positive radiative forcing by altering the surface albedo. For example, replacing forests with croplands or urban areas reduces the amount of solar radiation reflected back into space, increasing the net energy absorbed by the Earth's surface.

Negative radiative forcing, on the other hand, occurs when there is a decrease in the net energy flux into the Earth's climate system, leading to cooling. Several factors contribute to negative radiative forcing:

1. Aerosols and Particulate Matter: Certain types of aerosols, such as sulfate aerosols, reflect sunlight back into space, reducing the amount of solar radiation reaching the Earth's surface. This effect, known as aerosol direct radiative forcing, has a cooling influence on the climate.

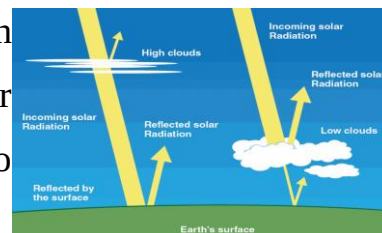




2. Volcanic Eruptions: Major volcanic eruptions release large quantities of sulfur dioxide (SO_2) into the stratosphere, forming sulfate aerosols that reflect sunlight and cause temporary cooling. The cooling effect from volcanic eruptions can last for several years, depending on the

magnitude of the eruption.

3. Cloud Cover Changes: Increased cloud cover can lead to negative radiative forcing by reflecting more solar radiation back into space. This process, known as cloud albedo effect, helps to cool the Earth's surface.



The overall impact of radiative forcing on the Earth's climate depends on the balance between positive and negative forcing factors. Human activities, such as the burning of fossil fuels and deforestation, have significantly increased positive radiative forcing, leading to global warming. However, natural processes and certain human-induced activities, such as the emission of reflective aerosols, contribute to negative radiative forcing and help offset some of the warming.

Understanding positive and negative radiative forcing is essential for comprehending the complex interactions within the Earth's climate system. By examining the factors that contribute to warming and cooling, scientists can better predict and mitigate the impacts of climate change. Effective climate policies and actions require a nuanced understanding of radiative forcing to balance the competing influences and ensure a stable and sustainable climate for future generations.

1.2* Comprehension Questions:

1. What is radiative forcing, and why is it important in the context of climate science?
2. How do greenhouse gas emissions contribute to positive radiative forcing?

3. Explain how aerosols can have both positive and negative radiative forcing effects.
4. What is the impact of volcanic eruptions on radiative forcing?
5. How does increased cloud cover contribute to negative radiative forcing?

1.3* Vocabulary and Terminology:

a) Define the following terms	b) Match the terms to their definitions
1. Radiative forcing	c) Tiny particles or droplets in the atmosphere that can reflect or absorb sunlight.
2. Greenhouse gas emissions	b) Gases released into the atmosphere that contribute to the greenhouse effect.
3. Aerosols	d) The reflectivity of a surface, usually referring to how much sunlight is reflected.
4. Albedo	e) Natural events that release large quantities of gases and particles into the atmosphere.
5. Volcanic eruptions	a) The measure of change in energy flux in the atmosphere due to natural and human activities.

1.4* Write a brief summary of the text in 5-6 sentences.

1.5* Discussion Prompts:

1. Discuss the role of greenhouse gases in positive radiative forcing. How do they affect the Earth's energy balance and contribute to global warming?
2. Explore the dual role of aerosols in radiative forcing. How can aerosols both warm and cool the climate? Provide examples.

3. Reflect on the effects of volcanic eruptions on the climate. How do these events contribute to negative radiative forcing, and what are the short-term and long-term impacts?

4. Analyze the importance of cloud cover in climate regulation. How does increased cloud cover lead to cooling, and what factors influence cloud formation?

5. Debate the overall impact of human activities on radiative forcing. How do our actions influence the balance between positive and negative radiative forcing?

1.6* Research and Presentation:

1. Conduct research on the impact of specific greenhouse gases on radiative forcing. Prepare a presentation detailing how different gases contribute to positive radiative forcing and their relative importance in global warming.

2. Explore the role of interdisciplinary collaboration in studying radiative forcing. Identify how climatologists, chemists, and engineers work together to understand and address the impacts of radiative forcing on climate change. Present your findings and discuss the importance of such collaboration.

Text 2

2.1* Read and translate the following texts Pay attention to the use of terminology in the text. Be attentive while choosing the adequate Ukrainian equivalents to the above-mentioned terms:

The Principles of Atmospheric Physics

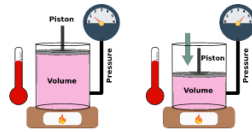
Atmospheric physics is a branch of meteorology that focuses on understanding the physical processes and phenomena occurring in the Earth's atmosphere. By applying the fundamental principles of physics, scientists can gain insights into weather patterns, climate behavior, and atmospheric dynamics. The following are some of the core

principles of atmospheric physics that play a crucial role in shaping our understanding of the atmosphere:

The behavior of gases in the atmosphere is governed by the gas laws, such as

Boyle's Law

$$V \propto 1/P$$



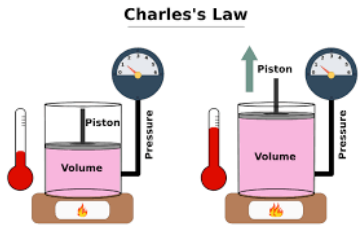
Boyle's law, Charles's law, and the ideal gas

law. These laws describe the relationships

between pressure, temperature, and volume

for ideal gases. The Earth's atmosphere is

composed of a mixture of gases, including



nitrogen (78%), oxygen (21%), and trace amounts of other gases such as carbon dioxide, methane, and water vapor. Understanding the composition and behavior of these gases is essential for studying atmospheric processes.

Thermodynamics is the study of energy and heat transfer, which are fundamental to atmospheric physics. The first law of thermodynamics, also known as the law of energy conservation, states that energy cannot be created or destroyed, only transformed. In the atmosphere, heat is transferred through conduction, convection, and radiation. Conduction occurs when heat is transferred through direct contact, convection involves the movement of heated air masses, and radiation is the transfer of energy through electromagnetic waves.

The atmosphere behaves as a fluid, and fluid dynamics principles are crucial for understanding wind patterns and atmospheric circulation. The Navier-Stokes equations describe the motion of fluid substances and are used to model atmospheric flows. These equations take into account factors such as pressure gradients, Coriolis force (due to the Earth's rotation), and friction. The general circulation of the atmosphere, including trade winds, jet streams, and cyclones, can be explained using fluid dynamics.

Atmospheric pressure decreases with altitude due to the decreasing weight of the overlying air. This relationship is described by the barometric formula, which provides an exponential decrease in pressure with height. Understanding atmospheric pressure variations is important for weather forecasting and aviation. The troposphere, the lowest

layer of the atmosphere, experiences the most significant changes in pressure and is where most weather phenomena occur.

The Earth's energy budget is a balance between incoming solar radiation and outgoing infrared radiation. The Sun emits shortwave radiation, which is absorbed by the Earth's surface and re-emitted as longwave infrared radiation. Greenhouse gases in the atmosphere trap some of this infrared radiation, leading to the greenhouse effect. This energy balance is crucial for maintaining the Earth's climate and is influenced by factors such as albedo (reflectivity) and cloud cover.

Atmospheric stability refers to the tendency of air parcels to rise or sink, which is influenced by temperature gradients and buoyancy. Stable atmospheres resist vertical motion, while unstable atmospheres promote it. Lapse rates, which describe how temperature changes with altitude, are key to determining stability. Weather systems, such as thunderstorms, hurricanes, and frontal systems, are driven by instability and the interaction of air masses.

The water cycle is a fundamental process in atmospheric physics, involving the evaporation, condensation, and precipitation of water. Humidity, or the amount of water vapor in the air, plays a critical role in weather patterns and cloud formation. Relative humidity, dew point, and specific humidity are important metrics for understanding moisture content in the atmosphere. The phase changes of water release or absorb latent heat, influencing atmospheric dynamics.

The principles of atmospheric physics provide a framework for understanding the complex interactions and processes within the Earth's atmosphere. By applying concepts from thermodynamics, fluid dynamics, and radiation, scientists can unravel the mysteries of weather patterns, climate change, and atmospheric behavior. Continued research in this field is essential for improving weather forecasting, mitigating the impacts of climate change, and enhancing our knowledge of the natural world.

2.2* Comprehension Questions:

1. What are the main components of the Earth's atmosphere, and what percentages do they represent?
2. Explain the first law of thermodynamics and its significance in atmospheric physics.
3. How do the Navier-Stokes equations contribute to our understanding of atmospheric circulation?
4. Describe the relationship between atmospheric pressure and altitude, and explain the significance of the barometric formula.
5. What is the Earth's energy budget, and how does it relate to the greenhouse effect?

2.3* Vocabulary and Terminology:

a) Define the following terms	b) Match the terms to their definitions
1. Gas laws	b) The branch of physics that deals with energy and heat transfer.
2. Thermodynamics	e) The balance between incoming solar radiation and outgoing infrared radiation.
3. Fluid dynamics	c) The principles governing the motion and behavior of fluids.
4. Atmospheric pressure	d) The force exerted by the weight of the atmosphere.
5. Energy budget	a) The study of the relationships between pressure, temperature, and volume of gases.

2.4* Summarize the text in 5-6 sentences.

2.5* Discussion Prompts:

1. Discuss the importance of gas laws in understanding the behavior of gases in the Earth's atmosphere. How do these laws apply to atmospheric phenomena?
2. Explore the role of thermodynamics in atmospheric physics. How do heat transfer processes, such as conduction, convection, and radiation, influence weather and climate?
3. Reflect on the significance of fluid dynamics in modeling wind patterns and atmospheric circulation. How do the Navier-Stokes equations help predict weather systems?
4. Analyze the relationship between atmospheric pressure and altitude. How does this relationship impact weather forecasting and aviation?
5. Debate the importance of the Earth's energy budget in maintaining climate stability. How do factors such as albedo and cloud cover influence the energy balance?

2.6* Research and Presentation:

1. Conduct research on the composition of the Earth's atmosphere. Prepare a presentation detailing the major and trace gases, their sources, and their roles in atmospheric processes.
2. Select a specific weather phenomenon, such as a thunderstorm or hurricane. Analyze the thermodynamic and fluid dynamic processes involved in its formation and development. Present your findings.
3. Explore the role of interdisciplinary collaboration in atmospheric physics. Identify how meteorologists, physicists, and climate scientists work together to study and predict atmospheric phenomena. Present your findings and discuss the importance of such collaboration.

TEST YOURSELF

1. What does physics study?
 - A) Heat transfer science.
 - B) Matter, energy, and fundamental forces.
 - C) Fundamental knowledge.
 - D) Human psychology.
2. Why is physics called the "fundamental science"?
 - A) It explains natural phenomena using simpler concepts.
 - B) It was the first science to be discovered.
 - C) It only studies microscopic particles.
 - D) It focuses only on theoretical models.
3. Which scientist developed the theory of relativity?
 - A) Isaac Newton.
 - B) Niels Bohr.
 - C) Albert Einstein.
 - D) James Clerk Maxwell.
4. Which branch of physics deals with the behavior of particles on a very small scale?
 - A) Thermodynamics.
 - B) Electromagnetism.
 - C) Quantum mechanics.
 - D) Classical mechanics.
5. What did Max Planck contribute to modern physics?
 - A) The theory of evolution.
 - B) The concept of discrete energy levels (quantum theory).
 - C) The laws of motion.
 - D) The discovery of electricity.
6. Which branch of physics deals with the motion of macroscopic objects and the forces acting upon them?

- A) Quantum Mechanics
- B) Electromagnetism
- C) Classical Mechanics
- D) Astrophysics

7. What principle is introduced in quantum mechanics that challenges classical intuition?

- A) Thermodynamics
- B) Quantum Entanglement
- C) Time Dilation
- D) Space-time Curvature

8. Which scientist is known for developing the theories of special and general relativity?

- A) Newton
- B) Galileo
- C) Planck
- D) Einstein

9. What is the primary focus of astrophysics?

- A) Study of electric and magnetic fields
- B) Study of celestial objects and phenomena
- C) Study of heat, energy, and work
- D) Study of atomic nuclei

10. Which branch of physics investigates the smallest building blocks of the universe?

- A) Thermodynamics
- B) Particle Physics
- C) Nuclear Physics
- D) Electromagnetism

11. What principle allows quantum computers to perform operations beyond the capabilities of classical computers?

- A) Superposition and Entanglement
- B) Classical Mechanics

C) Waveguides

D) Thermal Conduction

12. Which branch of physics extends electromagnetism by studying electric and magnetic fields in dynamic situations?

A) Quantum Mechanics

B) Electrodynamics

C) Statistical Mechanics

D) Cosmology

13. What does the kinetic theory describe?

A) The propagation of electromagnetic waves

B) The behavior of gases in terms of the motion of their individual molecules

C) The structure of crystals

D) The interaction of electric and magnetic fields

14. What is studied in crystallography?

A) The structure, properties, and formation of crystals

B) The behavior of subatomic particles

C) The principles of superposition and entanglement

D) The expansion of the universe

15. Which theory predicts gravitational waves?

A) Quantum Field Theory

B) General Theory of Relativity

C) Kinetic Theory

D) Maxwell's Equations

16. What is superposition in quantum mechanics?

A) The principle that particles can exist in multiple states simultaneously until measured

B) The concept that particles travel in straight lines

C) The idea that particles have fixed positions

- D) The theory that particles do not interact with each other
17. What is quantum entanglement?
- A) The phenomenon where particles travel in circles.
 - B) The interaction between particles and magnetic fields.
 - C) The state where two or more particles instantly influence each other regardless of distance.
 - D) The movement of particles in a wave-like manner.
18. Which experiment best illustrates wave-particle duality?
- A) Double-slit experiment
 - B) Photoelectric effect experiment
 - C) Rutherford's gold foil experiment
 - D) Stern-Gerlach experiment
19. Which of the following is an application of quantum computing?
- A) Solving complex problems in cryptography
 - B) Enhancing photographic resolution
 - C) Improving fuel efficiency in cars
 - D) Analyzing weather patterns
20. What are semiconductors used for in modern electronics?
- A) Storing thermal energy
 - B) Building transistors and integrated circuits
 - C) Generating nuclear power
 - D) Detecting gravitational waves
21. What does thermodynamics study?
- A) Only the behavior of gases.
 - B) The relationships between heat, work, energy, and temperature.
 - C) The movement of electrical charges.
 - D) The motion of objects in space.
22. Which of the following is not a branch of thermodynamics?

- A) Classical Thermodynamics.
- B) Chemical Thermodynamics.
- C) Mechanical Thermodynamics.
- D) Statistical Thermodynamics.

23. Which type of system does not exchange mass or energy with its surroundings?

- A) Open system.
- B) Closed system.
- C) Isolated system.
- D) Equilibrium system.

24. What is an example of a closed system?

- A) A steam turbine.
- B) A refrigerator.
- C) A balloon bursting.
- D) The universe.

25. What happens in a reversible process?

- A) The system stays in equilibrium at each step.
- B) The system undergoes an irreversible transformation.
- C) The process occurs suddenly and cannot be reversed.
- D) Energy is destroyed.

26. The word combination *thermal decay* is translated into Ukrainian as

- A) теплова ізоляція
- B) теплова інерція
- C) теплове розширення
- D) тепловий розпад.

27. What happens to a fluid when it is heated?

- A) It becomes denser and sinks.
- B) It expands and rises.

- C) It contracts and remains still.
 - D) It turns into a solid.
28. Which of the following materials is the best conductor of heat?
- A) Wood
 - B) Glass
 - C) Copper
 - D) Plastic
29. What is the process called when a liquid turns into a gas?
- A) Condensation
 - B) Freezing
 - C) Evaporation
 - D) Melting
30. Heat transfer by convection occurs in:
- A) Solids only
 - B) Liquids and gases
 - C) Metals only
 - D) Vacuum
31. What is radiation in terms of heat transfer?
- A) The transfer of heat through direct contact.
 - B) The transfer of heat by movement of fluids.
 - C) The transfer of heat by electromagnetic waves.
 - D) The transfer of heat through solids only.
32. Why can radiation occur in a vacuum?
- A) Because it does not require matter to transfer heat.
 - B) Because particles move faster in a vacuum.
 - C) Because air molecules carry the heat.
 - D) Because heat energy is absorbed by space.
33. Which of the following objects radiates the most energy?

- A) A cup of cold water.
- B) A warm mug of coffee.
- C) The Sun.
- D) A piece of ice.

34. What type of electromagnetic waves do objects at room temperature mostly emit?

- A) Ultraviolet waves.
- B) Infrared waves.
- C) X-rays.
- D) Radio waves.

35. How can infrared radiation be detected?

- A) By using a regular digital camera.
- B) By measuring the temperature with a thermometer.
- C) By using an infrared camera.
- D) By observing the object's color with the naked eye.

36. What does electromagnetism describe?

- A) The interaction between gravitational and electric forces.
- B) The interaction between electric charges and magnetic fields.
- C) The movement of heat through conductors.
- D) The effect of sound waves on charged particles.

37. The word "electromagnetism" comes from Greek words meaning:

- A) "Electric force and magnetic energy".
- B) "Lightning and iron".
- C) "Amber and Magnesian stone".
- D) "Electricity and conduction".

38. What is a fundamental characteristic of electric charge?

- A) Only electrons have charge.
- B) Like charges attract, and opposite charges repel.

- C) Opposite charges attract, and like charges repel.
- D) Charges do not interact with each other.

39. What happens when an electric charge moves?

- A) It generates a gravitational field.
- B) It creates both an electric and a magnetic field.
- C) It loses its charge.
- D) It stops interacting with other charges.

40. Which of the following is NOT a unit used in electromagnetism?

- A) Ampere (A).
- B) Volt (V).
- C) Newton (N).
- D) Tesla (T).

41. What are solar panels primarily used for?

- A) Storing wind energy
- B) Converting sunlight into electricity
- C) Producing geothermal heat
- D) Generating biomass energy

42. Which renewable energy source uses wind turbines to generate electricity?

- A) Solar energy
- B) Geothermal energy
- C) Wind energy
- D) Biomass energy

43. What is one of the main benefits of hydroelectric power?

- A) It uses fossil fuels
- B) It produces high carbon emissions
- C) It provides clean energy and helps with water management
- D) It relies on geothermal heat

44. Geothermal energy is derived from:

- A) Solar radiation
- B) The Earth's internal heat
- C) Wind currents
- D) Ocean tides

45. Biomass energy is generated from:

- A) Fossil fuels
- B) Organic materials such as plant and animal waste
- C) Nuclear reactions
- D) Geothermal reservoirs

46. What is one way nanotechnology can improve consumer products?

- A) By increasing the shelf life of food products through antimicrobial nanocoatings
- B) By creating new genres of music
- C) By developing faster internet connections
- D) By designing new architectural styles

47. What is a potential ethical consideration related to nanotechnology?

- A) The taste of new food products
- B) Privacy and security concerns
- C) The popularity of nanotechnology among teenagers
- D) The aesthetics of nanotechnology devices

48. Which is the best way to translate the following sentence:

Nanotechnology involves the manipulation of matter on an atomic and molecular scale.

- A) Нанотехнологія включає маніпуляції з матерією на атомарному та молекулярному рівнях.
- B) Нанотехнологія охоплює вивчення планет і зірок.
- C) Нанотехнологія займається створенням великих будівельних споруд.
- D) Нанотехнологія фокусується на вивченні кліматичних змін.

49. Which is the best way to translate the following sentence:

Nanoparticles can be engineered to deliver drugs directly to cancer cells.

- A) Наночастинки можна розробити для доставки ліків безпосередньо до ракових клітин.
- B) Наночастинки використовуються для будівництва великих мостів.
- C) Наночастинки можуть допомогти в утилізації відходів.
- D) Наночастинки слугують для покращення якості повітря.

50. What role does nanotechnology play in electronics and computing?

- A) Reducing food waste
- B) Improving the efficiency of solar panels
- C) Miniaturizing electronic components and increasing computing power
- D) Enhancing agricultural yields

ABBREVIATIONS

DNA	Deoxyribonucleic Acid
LHC	Large Hadron Collider
MRI	Magnetic Resonance Imaging
EHT	Event Horizon Telescope
CERN	European Organization for Nuclear Research (фр. Conseil Européen pour la Recherche Nucléaire)
CMS	Compact Muon Solenoid
EHT	Event Horizon Telescope
GPS	global positioning systems
PV	photovoltaic cells
CNTs	Carbon nanotubes
SWCNTs	single-walled nanotubes
MWCNTs	multi-walled nanotubes
DES	Dark Energy Survey
CMB	cosmic microwave background
SDSS	Sloan Digital Sky Survey
LSST	Large Synoptic Survey Telescope
QCD	quantum chromodynamics
LQG	Loop Quantum Gravity
CDT	Causal Dynamical Triangulations
DC	direct current

MRI	Magnetic Resonance Imaging
AC	alternating current
QCD	Quantum Chromodynamics

GLOSSARY OF PHYSICAL TERMS

A

Acceleration - the rate of increase of speed or the rate of change of velocity.

Alternating current - a continuous electric current that periodically reverses direction, usually sinusoidally.

Ampere - the basic SI unit of electric current; the constant current that, when maintained in two parallel conductors of infinite length and negligible cross section placed 1 metre apart in free space, produces a force of 2×10^{-7} newton per metre between them. 1 ampere is equivalent to 1 coulomb per second.

Amplifier - an electronic device used to increase the strength of the signal fed into it.

Angstrom - a unit of length equal to 10^{-10} metre, used principally to express the wavelengths of electromagnetic radiations. It is equivalent to 0.1 nanometre.

Anion - a negatively charged ion; an ion that is attracted to the anode during electrolysis.

Antimatter - a form of matter composed of antiparticles, such as antihydrogen, consisting of antiprotons and positrons.

Atom - this entity as a source of nuclear energy.

B

Baryon - any of a class of elementary particles that have a mass greater than or equal to that of the proton, participate in strong interactions, and have a spin of $\frac{1}{2}$. Baryons are either nucleons or hyperons. The baryon number is the number of baryons in a system minus the number of antibaryons.

Becquerel - the derived SI unit of radioactivity equal to one disintegration per second.

Boyle's law - the principle that the pressure of a gas varies inversely with its volume at constant temperature.

Brownian motion - random movement of microscopic particles suspended in a fluid, caused by bombardment of the particles by molecules of the fluid. First observed in 1827, it provided strong evidence in support of the kinetic theory of molecules.

C

Calorie - a unit of heat, equal to 4.1868 joules (International Table calorie): formerly defined as the quantity of heat required to raise the temperature of 1 gram of water by 1°C under standard conditions. It has now largely been replaced by the joule for scientific purposes.

Capacitance - the property of a system that enables it to store electric charge.

Cathode ray - a valve in which a beam of high-energy electrons is focused onto a fluorescent screen to give a visible spot of light. The device, with appropriate deflection equipment, is used in television receivers, visual display units, oscilloscopes, etc.

Centre of gravity - the point through which the resultant of the gravitational forces on a body always acts.

Centrifugal force - a fictitious force that can be thought of as acting outwards on any body that rotates or moves along a curved path.

Centripetal force - a force that acts inwards on any body that rotates or moves along a curved path and is directed towards the centre of curvature of the path or the axis of rotation.

Charge - the attribute of matter by which it responds to electromagnetic forces responsible for all electrical phenomena, existing in two forms to which the signs negative and positive are arbitrarily assigned.

Charles' law - the principle that all gases expand equally for the same rise of temperature if they are held at constant pressure: also that the pressures of all gases increase equally for the same rise of temperature if they are held at constant volume. The law is now known to be only true for ideal gases.

Conductor - a substance, body, or system that conducts electricity, heat, etc.

Convection - the process by which masses of relatively warm air are raised into the atmosphere, often cooling and forming clouds, with compensatory downward movements of cooler air.

Cosmic ray - a radiation of high penetrating power that originates in outer space and consists partly of high-energy atomic nuclei.

Coulomb - the derived SI unit of electric charge; the quantity of electricity transported in one second by a current of 1 ampere.

Current - a flow of electric charge through a conductor.

Cyclotron - a type of particle accelerator in which the particles spiral inside two D-shaped hollow metal electrodes placed facing each other under the effect of a strong vertical magnetic field, gaining energy by a high-frequency voltage applied between these electrodes.

D

Decibel - a unit for comparing two currents, voltages, or power levels, equal to one tenth of a bel.

Density - a measure of the compactness of a substance, expressed as its mass per unit volume. It is measured in kilograms per cubic metre or pounds per cubic foot.

Diffraction - a deviation in the direction of a wave at the edge of an obstacle in its path.

Diffusion - the random thermal motion of atoms, molecules, clusters of atoms, etc, in gases, liquids, and some solids.

Diode - a semiconductor device containing one p-n junction, used in circuits for converting alternating current to direct current.

Direct current - a continuous electric current that flows in one direction only, without substantial variation in magnitude.

Doppler effect - a phenomenon, observed for sound waves and electromagnetic radiation, characterized by a change in the apparent frequency of a wave as a result of relative motion between the observer and the source.

E

Earth - a connection between an electrical circuit or device and the earth, which is at zero potential.

Electricity - any phenomenon associated with stationary or moving electrons, ions, or other charged particles.

Electromotive force - a source of energy that can cause a current to flow in an electrical circuit or device.

Electron - a stable elementary particle presents in all atoms, orbiting the nucleus in numbers equal to the atomic number of the element in the neutral atom; a lepton with a negative charge of $1.602\,176\,462 \times 10^{-19}$ coulomb, a rest mass of $9.109\,381\,88 \times 10^{-31}$ kilogram, a radius of $2.817\,940\,285 \times 10^{-15}$ metre, and a spin of.

Energy - a measure of this capacity, expressed as the work that it does in changing to some specified reference state. It is measured in joules (SI units).

F

Farad - the derived SI unit of electric capacitance; the capacitance of a capacitor between the plates of which a potential of 1 volt is created by a charge of 1 coulomb.

Field - a region of space that is a vector field; a region of space under the influence of some scalar quantity, such as temperature.

Fission - the splitting of an atomic nucleus into approximately equal parts, either spontaneously or as a result of the impact of a particle usually with an associated release of energy.

Fluorescence - the emission of light or other radiation from atoms or molecules that are bombarded by particles, such as electrons, or by radiation from a separate source. The bombarding radiation produces excited atoms, molecules, or ions and these emit photons as they fall back to the ground state.

Force - a dynamic influence that changes a body from a state of rest to one of motion or changes its rate of motion. The magnitude of the force is equal to the product of the mass of the body and its acceleration.

Frequency - the number of times that a periodic function or vibration repeats itself in a specified time, often 1 second. It is usually measured in hertz

Friction - a resistance encountered when one body moves relative to another body with which it is in contact.

Fuse - a lead of combustible black powder in a waterproof covering (safety fuse), or a lead containing an explosive (detonating fuse), used to fire an explosive charge.

Fusion - a reaction in which two nuclei combine to form a nucleus with the release of energy.

G

Gamma ray - electromagnetic radiation having a wavelength of 10^{-9} centimeters or less: may be produced by the reactions of nuclei or elementary particles or by the interaction of high energy electrons with matter.

Generator - any device for converting mechanical energy into electrical energy by electromagnetic induction, esp a large one as in a power station.

Gravitational wave - a wave-like motion in a gravitational field, produced when a mass is accelerated or otherwise disturbed; they travel through space-time at the speed of light and the strongest sources are those with the strongest gravitational fields, although the waves are very weak; predicted by Einstein in 1916 but not first observed directly until 2015.

Gravity - the force of attraction that moves or tends to move bodies towards the centre of a celestial body, such as the earth or moon.

H

Half-life - the time taken for half of the atoms in a radioactive material to undergo decay.

Hertz - the derived SI unit of frequency; the frequency of a periodic phenomenon that has a periodic time of 1 second; 1 cycle per second.

Hyperon - any baryon that is not a nucleon.

I

Impetus - the force that sets a body in motion or that tends to resist changes in a body's motion.

Inductance - the property of an electric circuit as a result of which an electromotive force is created by a change of current in the same circuit (self-inductance) or in a neighbouring circuit (mutual inductance). It is usually measured in henries.

Inertia - the tendency of a body to preserve its state of rest or uniform motion unless acted upon by an external force.

Infrared - the part of the electromagnetic spectrum with a longer wavelength than light but a shorter wavelength than radio waves; radiation with wavelength between 0.8 micrometres and 1 millimetre.

J

Joule - the derived SI unit of work or energy; the work done when the point of application of a force of 1 newton is displaced through a distance of 1 metre in the direction of the force. 1 joule is equivalent to 1 watt-second, 10⁷ ergs, 0.2390 calories, or 0.738 foot-pound.

K

Kelvin - the basic SI unit of thermodynamic temperature; the fraction 1/273.16 of the thermodynamic temperature of the triple point of water Symbol: K.

Kinetic energy - the energy of motion of a body, equal to the work it would do if it were brought to rest. The translational kinetic energy depends on motion through space, and for a rigid body of constant mass is equal to the product of half the mass times the square of the speed. The rotational kinetic energy depends on rotation about an axis, and for a body of constant moment of inertia is equal to the product of half the moment of inertia times the square of the angular velocity. In relativistic physics kinetic energy is equal to the product of the increase of mass caused by motion times the square of the speed of light. The SI unit is the joule but the electronvolt is often used in atomic physics.

L

Laser - a source of high-intensity optical, infrared, or ultraviolet radiation produced as a result of stimulated emission maintained within a solid, liquid, or gaseous medium. The photons involved in the emission process all have the same energy and phase so that the laser beam is monochromatic and coherent, allowing it to be brought to a fine focus

Lens - a device that diverges or converges a beam of electromagnetic radiation, sound, or particles.

Lepton - any of a group of elementary particles and their antiparticles, such as an electron, muon, or neutrino, that participate in electromagnetic and weak interactions and have a half-integral spin.

Luminescence - the emission of light at low temperatures by any process other than incandescence, such as phosphorescence or chemiluminescence.

M

Mass - a physical quantity expressing the amount of matter in a body. It is a measure of a body's resistance to changes in velocity (inertial mass) and also of the force experienced in a gravitational field (gravitational mass): according to the theory of relativity, inertial and gravitational masses are equal.

Matter - substance that occupies space and has mass, as distinguished from substance that is mental, spiritual, etc.

Meson - any of a group of elementary particles, such as a pion or kaon, that usually has a rest mass between those of an electron and a proton, and an integral spin. They are responsible for the force between nucleons in the atomic nucleus.

Microwave - electromagnetic radiation in the wavelength range 0.3 to 0.001 metres: used in radar, cooking, etc.

Moment - the product of a physical quantity, such as force or mass, and its distance from a fixed reference point.

Momentum - the product of a body's mass and its velocity.

Muon - a positive or negative elementary particle with a mass 207 times that of an electron and spin. It was originally called the mu meson but is now classified as a lepton.

N

Neutrino - a stable leptonic neutral elementary particle with very small or possibly zero rest mass and spin that travels at the speed of light. Three types exist, associated with the electron, the muon, and the tau particle.

Neutron - a neutral elementary particle with a rest mass of $1.674\,92716 \times 10^{-27}$ kilogram and spin; classified as a baryon. In the nucleus of an atom it is stable, but when free it decays.

Newton - the derived SI unit of force that imparts an acceleration of 1 metre per second to a mass of 1 kilogram; equivalent to 10⁵ dynes or 7.233 poundals.

Nucleon - a proton or neutron, esp one present in an atomic nucleus.

Nucleus - the central portion in the head of a comet, consisting of small solid particles of ice and frozen gases, which vaporize on approaching the sun to form the coma and tail.

O

Ohm - the derived SI unit of electrical resistance; the resistance between two points on a conductor when a constant potential difference of 1 volt between them produces a current of 1 ampere.

Ohm's law - the principle that the electric current passing through a conductor is directly proportional to the potential difference across it, provided that the temperature remains constant. The constant of proportionality is the resistance of the conductor.

P

Particle - a body with finite mass that can be treated as having negligible size, and internal structure.

Pascal - the derived SI unit of pressure; the pressure exerted on an area of 1 square metre by a force of 1 newton; equivalent to 10 dynes per square centimetre or 1.45×10^{-4} pound per square inch.

Planck constant or Planck's constant - a fundamental constant equal to the energy of any quantum of radiation divided by its frequency. It has a value of $6.62606876 \times 10^{-34}$ joule seconds.

Potential difference - the difference in electric potential between two points in an electric field; the work that has to be done in transferring unit positive charge from one point to the other, measured in volts.

Potential energy - the energy of a body or system as a result of its position in an electric, magnetic, or gravitational field. It is measured in joules (SI units), electronvolts, ergs, etc.

Proton - a stable, positively charged elementary particle, found in atomic nuclei in numbers equal to the atomic number of the element. It is a baryon with a charge of $1.602176462 \times 10^{-19}$ coulomb, a rest mass of $1.672\,62159 \times 10^{-27}$ kilogram, and spin.

Q

Quantum - the smallest quantity of some physical property, such as energy, that a system can possess according to the quantum theory.

R

Radiation - the emission or transfer of radiant energy as particles, electromagnetic waves, sound, etc.

Radioactivity - the spontaneous emission of radiation from atomic nuclei. The radiation can consist of alpha, beta, and gamma radiation.

Radio wave - an electromagnetic wave of radio frequency.

Red shift - a shift in the lines of the spectrum of an astronomical object towards a longer wavelength (the red end of an optical spectrum), relative to the wavelength of these lines in the terrestrial spectrum, usually as a result of the Doppler effect caused by the recession of the object.

Reflection - the act of reflecting or the state of being reflected.

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

Relativity - either of two theories developed by Albert Einstein, the special theory of relativity, which requires that the laws of physics shall be the same as seen by any two different observers in uniform relative motion, and the general theory of relativity which considers observers with relative acceleration and leads to a theory of gravitation.

Resistance - the opposition to a flow of electric current through a circuit component, medium, or substance. It is the magnitude of the real part of the impedance and is measured in ohms.

Rutherford - a unit of activity equal to the quantity of a radioactive nuclide required to produce one million disintegrations per second.

S

Semiconductor - a device, such as a transistor or integrated circuit, that depends on the properties of such a substance.

Simple harmonic motion - a form of periodic motion of a particle, etc, in which the acceleration is always directed towards some equilibrium point and is proportional to the displacement from this point.

Spectrum - the distribution of colours produced when white light is dispersed by a prism or diffraction grating. There is a continuous change in wavelength from red, the longest wavelength, to violet, the shortest. Seven colours are usually distinguished: violet, indigo, blue, green, yellow, orange, and red.

Static electricity - electric sparks or crackling produced by friction.

Superconductivity - the property of certain substances that have no electrical resistance. In metals it occurs at very low temperatures, but higher temperature superconductivity occurs in some ceramic materials.

Superfluidity - the state of being or property of becoming a superfluid.

surface tension - a property of liquids caused by intermolecular forces near the surface leading to the apparent presence of a surface film and to capillarity, etc.

T

Tau particle - an unstable, negatively charged lepton with a mass of c. 1,777 MeV/c² (or c. 3,490 times that of an electron) and a mean lifetime of 2.2×10^{-13} second.

Tension - a force that tends to produce an elongation of a body or structure.

terminal velocity - the constant maximum velocity reached by a body falling under gravity through a fluid, esp the atmosphere.

Thermostat - a device that maintains a system at a constant temperature. It often consists of a bimetallic strip that bends as it expands and contracts with temperature, thus breaking and making contact with an electrical power supply.

Transformer - a device that transfers an alternating current from one circuit to one or more other circuits, usually with an increase (step-up transformer) or decrease (step-

down transformer) of voltage. The input current is fed to a primary winding, the output being taken from a secondary winding or windings inductively linked to the primary.

Transistor - a semiconductor device, having three or more terminals attached to electrode regions, in which current flowing between two electrodes is controlled by a voltage or current applied to one or more specified electrodes. The device is capable of amplification, etc, and has replaced the valve in most circuits since it is much smaller, more robust, and works at a much lower voltage.

U

Ultraviolet - the part of the electromagnetic spectrum with wavelengths shorter than light but longer than X-rays; in the range 0.4×10^{-6} and 1×10^{-8} metres.

V

Vacuum - a region containing no matter; free space.

Velocity - a measure of the rate of motion of a body expressed as the rate of change of its position in a particular direction with time. It is measured in metres per second, miles per hour, etc.

Viscosity - a measure of this resistance, equal to the tangential stress on a liquid undergoing streamline flow divided by its velocity gradient. It is measured in newton seconds per metre squared.

Volt - the derived SI unit of electric potential; the potential difference between two points on a conductor carrying a current of 1 ampere, when the power dissipated between these points is 1 watt.

W

Watt - the derived SI unit of power, equal to 1 joule per second; the power dissipated by a current of 1 ampere flowing across a potential difference of 1 volt. 1 watt is equivalent to 1.341×10^{-3} horsepower.

Wave - one of a sequence of ridges or undulations that moves across the surface of a body of a liquid, esp the sea: created by the wind or a moving object and gravity.

Wavelength - the distance, measured in the direction of propagation, between two points of the same phase in consecutive cycles of a wave.

X

X-ray - electromagnetic radiation emitted when matter is bombarded with fast electrons.

X-rays have wavelengths shorter than that of ultraviolet radiation, that is less than about 1×10^{-8} metres. They extend to indefinitely short wavelengths, but below about 1×10^{-11} metres they are often called gamma radiation.

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20. Professional English in use: Math, physics and computer science: навчально-методичний посібник з англійської мови для студентів фізико-математичного напрямку (математика, фізика, комп'ютерні науки) / Укладачі: А.О. Трофименко, Н.А. Глушковецька, А.В. Дубінська, А.А. Крук. – Кам'янець-Подільський: ТОВ “Друкарня “Рута”, 2023. – 304 с.

Навчальне видання

**Навчальний посібник з англійської мови
для студентів фізико-технічних спеціальностей
вищих навчальних закладів**

Навчальний посібник

Упорядники:

Ліліана МАКОВІЙЧУК
Роксолана МЕЛЬНИЧУК