
HOMO RES SACRA

МИНИСТЕРСТВО НАУКИ И ВЫСШЕГО ОБРАЗОВАНИЯ РОССИЙСКОЙ ФЕДЕРАЦИИ

МИНИСТЕРСТВО ОБРАЗОВАНИЯ, НАУКИ, КУЛЬТУРЫ И СПОРТА РЕСПУБЛИКИ АРМЕНИЯ

РОССИЙСКО-АРМЯНСКИЙ (СЛАВЯНСКИЙ) УНИВЕРСИТЕТ

М.С. ЕСАЯН

АНГЛИЙСКИЙ ДЛЯ ФИЗИКОВ

Учебно-практическое пособие для студентов, обучающихся по направлению «Физико-технические науки»

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TEACHING AID FOR PHYSICISTS

Educational-practical manual
for students studying in the direction of
“Physical and technical sciences”

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Учебно-практическое пособие содержит основные и дополнительные тексты, упражнения по лексико-грамматике, а также задания для развития навыков письменной и устной речи, аудирования. Тексты подобраны с учетом функциональной и профессиональной направленности в области физики и инженерии, включая сокращенные версии современных материалов из английских и американских журналов.

Пособие предназначено для студентов инженерно-физического института Российско-Армянского (Славянского) государственного университета и специалистов в области физики, квантовой информатики и инженерии, в том числе научных сотрудников и аспирантов.

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СТРУКТУРА И СОДЕРЖАНИЕ УЧЕБНО-ПРАКТИЧЕСКОГО ПОСОБИЯ

Предлагаемое учебно-практическое пособие предназначено для студентов технических специальностей, в частности, инженерно-физического направления Российско-Армянского (Славянского) государственного университета.

Пособие предназначено для формирования языковой компетенции в сфере профессиональной коммуникации, что нашло свое отражение в структуре пособия. Целесообразно начинать работу с пособием после того, как студенты освоят базовые основы английской грамматики и значительное количество общеупотребительной лексики.

В подборе материала были представлены следующие принципы:

1. Аутентичность текстов, заимствованных из американских источников, дающих полное представление о предмете.

2. Изучение материала включает два аспекта: выявление специализированной терминологии, ориентированной на ее функциональное значение и развитие на основе коммуникативных умений.

Пособие включает 10 разделов (Units). Каждый раздел имеет тексты с выделенным активным и дополнительным словарями, вопросы, последующие тексты, и значительное количество лексических упражнений, направленных на максимальное усвоение студентами основных словарных единиц, используемых в области физики, а также на преодоление лингвистических сложностей в области многозначимости слов и синонимии – наряду с трудностями перевода.

В конце каждого раздела даются упражнения, направленные на развитие устной речи и аудирования. Коммуникативные упражнения стимулируют аргументированные высказывания, участие в дискуссиях на профессиональные темы.

Упражнения аудирования, которые осуществляется сканированием QR-кодов, направлены на развитие навыков восприятия устной информации, расширение словарного запаса в области физики и повышения понимания контекста на слух.

В пособие включены дополнительные материалы в разделах Great Minds in the History of Physics, Modern Physics, а также Appendix и глоссарий (Basic Vocabulary of Physics).

Учебно-практическое пособие может быть полезно для студентов физико-технического профиля бакалавра, магистрантов и аспирантов.

Пособие ориентировано на всех, кто интересуется научной терминологией и инженерно-физическим образованием.

PART I

UNIT I.

Ex. I. Read the text paying attention to the new vocabulary:

The laws of physics is the canvas God laid down on which to paint his masterpiece
Dan Brown

THE NATURE OF PHYSICS

Physics is a branch of science. The word science comes from a Latin word that means having knowledge, and refers the knowledge of how the physical world operates, based on objective evidence determined through observation and experimentation. Physics is the science aimed at describing the fundamental aspects of our universe. This includes what things are in it, what properties of those things are noticeable, and what processes those things or their properties undergo. In simpler terms, physics attempts to describe the basic mechanisms that make our universe behave the way it does.

Physics is one of the most ancient sciences about nature. The word "physics" takes its origin from the Greek word "phusis" meaning nature.

The development of other sciences depends in many respects on the knowledge of physical phenomena. Physics divides itself very naturally into two great branches, experimental physics and theoretical physics. The former is the science of making observations and devising experiments which give us accurate knowledge of the actual behavior of natural phenomena. On the basis of experimental facts theoretical physics formulates laws and predicts the behavior of natural phenomena. Every physical law is based on experiments and is devised to correlate and to describe accurately these experiments. The wider the range of experience covered by such a law, the more important it is.

As our technology evolved over the centuries, physics expanded into many branches. Ancient peoples could only study things that they could see with the naked eye or otherwise experience without the aid of scientific equipment. This included the study of kinematics, which is the study of moving objects. For example, ancient people often studied the apparent motion of objects in the sky, such as the sun, moon, and stars. This is evident in the construction of prehistoric astronomical observatories, such as Stonehenge in England or Qarahunj in the Syunik Province of Armenia.

The study of nature later came to be called natural philosophy. From ancient times through the Renaissance, natural philosophy encompassed many fields, including astronomy, biology, chemistry, mathematics, and medicine. Over the last few centuries, the growth of scientific knowledge has resulted in ever-increasing specialization and branching of natural philosophy into separate fields. Physics, as it developed from the Renaissance to the end of the 19th century, is called classical physics. Revolutionary discoveries starting at the beginning of the 20th century transformed physics from classical physics to modern physics.

Modern physics is divided into half a dozen or more different fields-mechanics, sound, heat, electricity and magnetism, light, molecular, atomic and nuclear physics. These different fields are not distinct but merge into each other.

In all cases physics deals primarily with phenomena that can be accurately described in terms of matter and energy. Hence, the basic concepts in all physical phenomena are the concepts of matter and energy. Therefore, it is important to determine accurately the characteristics of both matter and energy, the laws that govern their transformations, and the fundamental relations that exist between them.

Study the basic vocabulary

Word	Pronunciation	Translation
Accurately, adv	/ˈækjərətli/	точно, ճշգրիտ
Behavior, n	/bɪˈheɪvjə(r)/	поведение, պահվածք
Concept, n	/ˈkɒnsept/	понятие, идея, երևույթ
Conventional, adj	/kənˈvenʃənl/	традиционный, ավանդական
Charge, n	/tʃɑːdʒ/	заряд, լիցք
Devise, v	/dɪˈvaɪz/	придумывать, разрабатывать, հնարել, նախագծել

Depend on, v	/dɪˈpend/	зависеть от, կախված լինել
Describe, v	/dɪˈskraɪb/	описывать, նկարագրել
Determine, v	/dɪˈtɜːmɪn/	устанавливать, определять, սահմանել, որոշել
Encompass, v	/ɪnˈkʌm.pəs/	охватывать, ընդգրկել
Equal, v	/ˈiːkwəl/	равный, հավասար
Evident, n	/ˈev.ɪ.dənt/	очевидный, ակնհայտ, պարզ
Indicate, v	/ˈɪndɪkeɪt/	указывать, свидетельствовать, մատնանշել
Investigation, n	/ɪnˌvestɪˈgeɪʃn/	расследование, հետազոտություն
Liquid, adj	/ˈlɪkwɪd/	жидкость, հեղուկ
Matter, n	/ˈmætə/	материя, մատերիա
Merge, v	/mɜːdʒ/	сливать(ся), соеди-нять(ся), ձուլվել
Naked eye		невооруженным глазом, անզեն աչք
Noticeable, adj	/ˈnəʊtɪsəbl/	заметный, նկատելի
Nuclear, adj	/ˈnjuːkliə/	ядерный, միջուկային
Nucleus, n	/ˈnjuːkliəs/	ядро, միջուկ
Particle, n	/ˈpɑːtɪkl/	частица, крупица, մասնիկ

Phenomenon, n	/fəˈnɒmɪnən/	феномен, явление, երևույթ
Primarily, adv	/ˈpraɪmərəli/	главным образом, առաջնային
Relation, n	/rɪˈleɪʃn/	связь, зависимость, կապ
Revolve, v	/rɪˈvɒlv/	вращаться, պտտվել
Solid, adj	/ˈsɒlɪd/	твердый, плотный, կարծր
State, n	/steɪt/	состояние, վիճակ
Substance, n	/ˈsʌbstəns/	вещество, նյութ
Surround, v	/səˈraʊnd/	окружать, շրջապատել
Transformation, n	/ˌtrænsfəˈmeɪʃn/	превращение, преобразование, փոխակերպում
Unit, n	/ˈjuːnɪt/	единица (измере-ния), չափման միավոր
Various, adj	/ˈveəriəs/	разный, различный, զանազան

Ex. II. Answer the questions on the text:

1. What is the text concerned with?
2. Which word does physics derive from?
3. What are the two main branches of physics?
4. What does theoretical physics formulate?
5. Which phenomena does physics study?

6. What fields does physics deal with?
7. What are the basic concepts in all physical phenomena?

Ex. III. Find the equivalents:

Actual	Иметь дело с/գործ ունենալ
On the basis of	Зависеть от/կախված լինել
To deal with	Вытекать из/բխել
To cover	С точки зрения/առումով
To derive from	Вращаться/պտտվել
In terms of	На основании/հիմքում
To be equal to	Охватывать/ծածկել
In respect to	Понятие/երևույթ
To revolve	На самом деле/փաստացի
To depend on	Что касается/ինչ վերաբերվում է
Concept	Равняться/հավասարվել

Ex. IV. Give Russian/Armenian equivalents for the following words and expressions:

To take origin, to devise experiment, magnetism, matter, range, in respect to, to determine, concept, distinct, observation, to correlate, molecular physics, atomic energy, accurately, transformation, fundamentals of physics, mechanical motion, to divide into, merge into, nuclear physics, growth of scientific knowledge, to determine accurately, wide range, revolutionary discoveries, prehistoric.

Ex. V. Give English equivalents for the following words and expressions:

Основывать/հիմնել, делить/բաժանել, наблюдать/դիտել, определять/սահմանել, положительный/դրական, отрицательный/բացասական заряд/լիցք, точный/ճշգրիտ, важный/կարևոր, различный/տարբեր, основной/հիմնական, состоять из/բաղկացած լինել, зависеть от/կախված լինել, явление/երևույթ, природа/բնություն, поведение/պահվածք, теория/տեսություն, закон/օրենք, равняться,/հավասարվել, на основании/հիման վրա, вращаться/պտտվել, иметь дело с/գործ ունենալ:

Ex. VI. Using dictionary write plural forms of the given terms of Latin and Greek origin:

Singular	**Plural**
Formula	
Maximum	
Medium	
Nucleus	
Phenomenon	
Quantum	
Radius	
Spectrum	
Thesis	

Ex. VII. Open the brackets using the nouns in their correct form:

1. Scientists are interested in studying the various (phenomenon) of nature.
2. You shouldn't base your argument only on your (analysis).
3. Mastering basic Access (formula) is essential for beginners.
4. We observed the (nucleus) which consist of protons and neutrons.
5. The best way to gain trust is to include (datum).

READING 2.

Matter

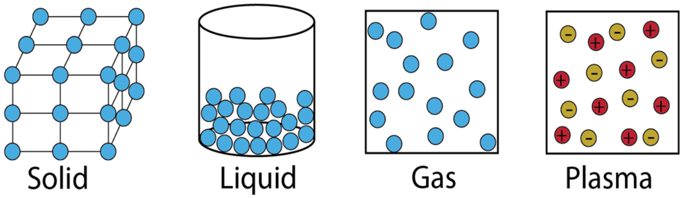
Every substance or material that we come in contact with or which is known to man can be divided into particles known as molecules. Chemical reactions indicate that the molecules are composed of smaller units, or atoms, and modern physical methods of investigation have shown that the atom consists of a centrally situated nucleus with a total positive charge surrounded by a number of electrons which revolve about the nucleus. In a stable atom, the total positive charge of the nucleus is equal to the total negative charge of the electrons which surround the nucleus. The total electrical charge is zero and this is the conventional state of most atoms. The state of matter can be changed by heating or cooling it or by changing the pressure conditions on it. When a material changes state, its molecules behave differently but don't break apart. Since they remain essentially the same, they don't form a different material but simply change the state of the existing material.

Matter can exist in four states: solid, gas, liquid and plasma. In **solid** materials, particles are tightly packed, which means they have a high density. All solids have a definite shape, mass and volume, which prevents them from conforming to the shape and volume of a container where they are kept. This is one of the properties that differentiates solid matter from liquid matter. Unlike solids, particles in **liquid** matter are more loosely packed. This enables them to flow around each other, which gives the liquid an indefinite shape. It is this lack of a specific shape that enables liquids to conform to the shape of containers. Liquids are also less dense than solids. Both solids and liquids are difficult to compress.

In **gaseous** matter, particles are spread out indefinitely since they have a lot of space between them. This space is also why atoms in gases have large vibrations, and particles have high kinetic energy.

Gases can also be confined, in which case they adjust to the volume and shape of the container that confines them. Unlike solids and liquids, gases can be compressed by reducing the size of the container, which then reduces the space between particles. A **plasma**, first identified in 1879, consists of highly charged particles with high kinetic energy. Typically, plasmas are gases that are ionized at high temperatures. Examples of these gases include helium, neon, argon, krypton, xenon and radon – all of which are noble gases and can be ionized into the plasma state.

Stars are a good example of plasmas in the real world. Fluorescent lights are also a type of plasma, even though they have different physical characteristics from stars.



Ex. I. Answer the following questions on the text:

1. What are molecules composed of?
2. Describe the structure of matter.
3. What does molecular physics study?
4. What does nuclear physics study?
5. What are the four states of matter?

Ex. II. Translate the following sentences into Russian/Armenian:

1. The development of other sciences depends in many respects on the knowledge of physical phenomena
2. Every physical law is based on experiments and is devised to correlate and to describe accurately these experiments.
3. Physics is divided into half a dozen or more different fields.

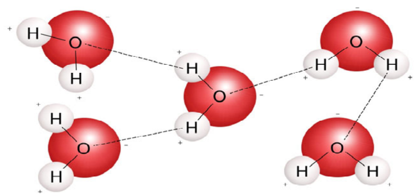
4. In all cases physics deals primarily with phenomena that can be accurately described in terms of matter and energy.
5. The wider the range of experience covered by such a law, the more important it is.

Ex. III. Render the text "Familiar Aspects of Matter"

Familiar Aspects of Matter

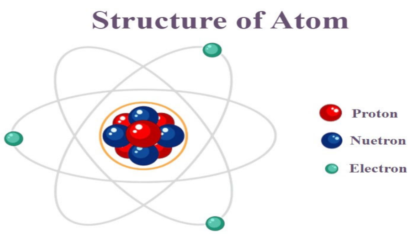
Matter was defined earlier as anything that has weight and that takes up space. Any body of matter is always a solid, a liquid, or a gas. Also, any substance is an *element*, a *compound*, or a *mixture*. **Element** is a simple substance, such as iron or nickel, that cannot be broken up into any simpler substance by ordinary chemical means, as a compound can. **Compound** is a substance that is composed of two or more chemical elements, and whose properties, or characteristics, differ from those of every element composing it. **A mixture** is material that is made up of separate elements or compounds or both. Air is described as a mixture of gases and dust. Solutions are mixtures. Thus water, as it occurs in nature, is a mixture. It is composed of pure water, dissolved oxygen and other gases from the air, minerals that have been dissolved out of rocks and soil, and minute plants and animals. We know that all matter is composed of molecule9s. Molecules are almost too small to be imagined. Yet in order to understand elements, compounds, and mixtures more fully, it is necessary to describe still smaller particles, namely, atoms. Molecules are solid bodies, like infinitely small balls. Yet every molecule is believed to consist largely of empty space. Within this space are the atoms that make up the molecule. Every kind of molecule is composed of a certain number of atoms. The kinds of atoms and the number of each kind are always the same for any substance. The molecule of an element, contains from 1 to 4 atoms. Thus, gold or iron has only 1 atom per molecule. Each of the common gaseous elements, such as oxygen or nitrogen, has 2. The molecule of the element phosphorus has 4. The numbers of atoms in the molecules of compounds vary from 2 to many. Thus, the carbon monoxide molecule has 2 atoms, one of carbon and the other of oxygen. The water molecule has 3 atoms – two of hydrogen and one of oxygen. The molecule of either cane sugar or beet sugar contains 45. Those of certain compounds that are parts of the bodies of living things contain many thousands.

Water molecule



To understand why different substances, have different properties, it is necessary to know something about electron theory. All scientists accept this theory, though they do not agree with respect to all details. Therefore, not all the statements that follow are known to be true. All, however, are considered reasonable in the light of abundant evidence. Here they will be stated as if they were accepted facts.

Inside the Atom. Like a molecule, an atom consists mostly of empty space. In the center of this space is a nucleus, or core. Inside the nucleus are one or more protons, and also the same or a larger number of neutrons, depending on the kind of atom (gold, oxygen, or other element). A proton is a positive particle of electricity. A neutron is a particle of about the same size and weight as a proton, but it has no electrical charge. Electrons circle around the nucleus. These electrons are particles of negative electricity. An electron is somewhat larger than a proton or a neutron, but it weighs only about one two-thousandth as much. There is 1 electron outside the nucleus for every proton inside it.



SPEAKING

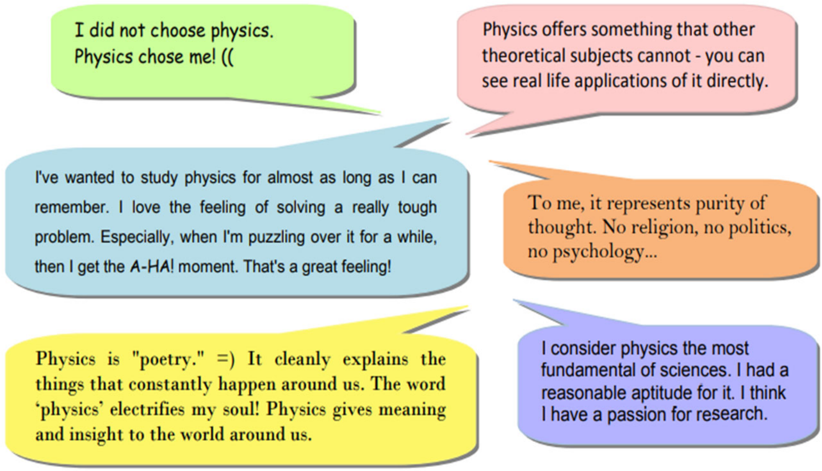
Ex. IV. Make a short presentation on the following topic.

What is the role of physics in everyday life?

Try to use the following expressions:

Firstly, first of all, to begin with, secondly
At the same time, in the meanwhile, for the time being
The reason for this is, the cause of this is
As a result of this, consequently, therefore

Ex. V. Work in small groups. Read the answers to the question "Why did you choose physics?" Why did you choose to do a physics course at university?



Ex. VI. Match the field of physics with the area(s) of its application:

NB! Each area of application can refer to more than one field of physics.

FIELDS OF PHYSICS	AREAS OF APPLICATION
1. Optics	a) to create large capacity disks
2. Biophysics	b) to develop medical imaging instrumentation
3. Radiophysics	c) to make new materials
4. Nuclear physics	d) to set up satellite communication
5. Nanophysics	e) to build telescopes
6. Condensed matter physics	f) to operate a nuclear reactor
7. Astrophysics	g) to produce computer chips
8. Particle physics	h) to design and create smart machines
9. Acoustics	i) to modify microorganisms for biofuel and bioelectricity
10. Mechanics	j) to develop atomic size machines
	k) to determine the age of an ancient object or a person
	l) to create better concert halls
	m) to develop lasers

GRAMMAR EXERCISES

Complete the sentences and the text. Use Present Simple or Present Continuous:

1. The sophomores (want) to improve the level of their English.

2. Therefore, they (do) a language course in London at the moment.
3. It (be) only a five-minute walk to the nearest station.
4. The train (leave) at half past eight.
5. The first lesson (begin) at 9 o'clock.
6. Unfortunately the university (not offer) sightseeing tours in and around London.
7. Currently the students of the language school (study) at Windsor.
8. She (work) in the laboratory right now.
9. We (not like) chemistry, we (like) physics.
10. Listen! Someone (play) the piano in the next room.

My cousin is a notorious violinist. He_____ (give) one or two concerts every month. He _____ (travel) a lot and this week he's in Tokyo. He_____ (stay) at a luxurious hotel. Currently he is at his hotel. He_____ (have) his lunch in the living room. He_____ (drink) a cup of tea and he______ (read) a morning paper. John is always very busy. He_____ (play) the violin regularly. He_____ (practise) for five hours daily. He_____ (go) to bed late and he always ______ (get up) very early. But he sometimes_____ (get) dressed too fast, and today he_____ (wear) one yellow sock and one green one!

Ex. VIII. Translate the sentences from English into Russian/Armenian paying attention to the Participle I construction:

1. The people working in the laboratory are famous scientists.

2. Physics is a broad science that deals primarily with phenomena involving the transformation of matter and energy.
3. Molecules are in rapid motion, the motion becoming more rapid with an increase of temperature.
4. The physicist observing the phenomena discovered new concepts.
5. Two objects being at the same temperature, the average energy of motion of their molecules in the same.
6. The students studying at the local school often visit international workshops.
7. While repairing the engine he found two broken parts.
8. Let's solve an equation using complex numbers.
9. Other things being equal, iron will oxidize more rapidly than mercury or silver.
10. The temperature being raised, the kinetic energy is increased.

Ex. IX. Translate the following sentences into English:

1. В течении тысячелетий людям были известны три состояния вещества.

Դարեր շարունակ մարդկությանը հայտնի է նյութի երեք վիճակ:

2. Четвертое состояние материи – плазма, находится во вселенной.

Նյութի չորրորդ վիճակը՝ պլազման, գտնվում է տիեզերքում:

3. Плазма твердого тела имеет высокую концентрацию заряженных частиц.

Պինդ վիճակում պլազման ունի լիցքավորված մասնիկների բարձր կոնցենտրացիա։

4. Солнце, звезды и молния представляют собой тоже плазму.

Արևը, աստղերն ու կայծակը նույնպես պլազմա են։

5. Плазма твердого тела обладает многими свойствами газовой плазмы.

Պինդ մարմնի պլազման ունի գազային պլազմայի բազմաթիվ հատկություններ։

LISTENING

Scan the QR code, watch the video and answer the questions on the topic:

1. What example is offered to describe the law of conservation of angular momentum?
2. What is the Hubble Space Telescope invented for?
3. How does the author offer to study complicated things in science?
4. What three life-support systems does the author mention?

Enjoy yourself

A chemistry professor chalked a formula HNO3 on the blackboard. Then he looked around and pointed a finger at the sleepiest member of the class.

"Identify that formula", he demanded.

"Eh, ah," started the unhappy student. "I've got it right on the tip of my tongue, sir".

"In that case," said the professor softly, "you'd better spit it out, my boy. It's nitric acid".

UNIT II.

Ex. I. Read the text paying attention to the new vocabulary:

Not everything that counts can be counted and
not everything that can be counted counts
Albert Einstein

UNITS OF MEASUREMENTS

Much of physics deals with measurements of physical quantities such as length, time, velocity, area, volume, mass, density, temperature and energy. Many of these quantities are interrelated. The measurements of physical quantities are expressed in terms of units, which are standardized values. For example, velocity is length divided by time. Density is mass divided by volume. Volume is a length times a second length, times a third length. Most of the physical quantities are related to length, time and mass, therefore all the systems of physical units are derived from these three fundamental units. The standard metre of the world was originally defined in terms of the distance from the North Pole to equator. This is close to 10,000 kilometres or 10^7 (ten to seventh power) metres. By international agreement the standard metre of the world is the distance between two scratches made on a platinum-alloy bar. It is kept at the International Bureau of Weights and Measures in France. The square metre (m^2) is an MKS unit of area while the cubic metre (m^3) is an MKS unit used to measure volume.

Some physical quantities are more fundamental than others. In physics, there are seven fundamental physical quantities that are measured in base or physical fundamental units: length, mass, time, electric current temperature, amount of substance, and luminous intensity. Units for other physical quantities (such as force, speed, and electric charge) described by mathematically combining these seven base units. In this course, we will mainly use five of these: length, mass, time, electric current and temperature. The units in which they are measured are the meter, kilogram, second, ampere, kelvin, mole, and candela. All other units are made by mathematically combining the fundamental units. These are called derived units.

SI Base Units			
Base quantity		**Base unit**	
Name	**Typical symbol**	**Name**	**Symbol**
time	*t*	second	s
length	*l*, *x*, *r*, etc.	meter	m
mass	*m*	kilogram	kg
electric current	*I*, *i*	ampere	A
thermodynamic temperature	*T*	kelvin	K
amount of substance	*n*	mole	mol
luminous intensity	I_v	candela	cd

Study the basic vocabulary

Word	Pronunciation	Translation
Adopt, v	/əˈdɒpt/	усвоить, принимать ընդունել
Commit, v	/kəˈmɪt/	совершать (что-либо дурное), կատարել
Conversion, n	/kənˈvɜːʃn/	переход (к чему-либо), փոխակեր-պում
Cubic, adj	/ˈkjuːbɪk/	кубический санти-метр, խորանարդ
Decimal, adj	/ˈdesɪml/	десятичный, տասնյակ
Dimension, n	/daɪˈmenʃn/	измерение, аспект, հարթություն, տարածություն
Divide, v	/dɪˈvaɪd/	разделять(ся), բաժանել
Density, n	/ˈdensəti/	плотность, խտություն
Derive, v	/dɪˈraɪv/	происходить, ծագել
Distance, n	/ˈdɪstəns/	расстояние, հեռավորություն
Equal, adj	/ˈiːkwəl/	равный, հավասար
Interpret, v	/ɪnˈtɜːprət/	истолковывать, մեկնաբանել

Modify, v	/ˈmɒdɪfaɪ/	модифицировать, փոփոխել
Multiply, v	/ˈmʌltɪplaɪ/	увеличивать(ся), размножать(ся), բազմապատկել
Obtain, v	/əbˈteɪn/	получать, ձեռք բերել
Refer, v	/rɪˈfɜː(r)/	обращаться к чему-либо, հղել, դիմել
Shift, n	/ʃɪft/	сдвиг, изменение, տեղափոխում
Square, adj	/skweə(r)/	квадрат, քառակուսի
Supplementary, adj	/ˌsʌplɪˈmentri/	дополнительный, հավելյալ
Unify, v	/ˈjuːnɪfaɪ/	объединять, միացնել, միավորել
Velocity, n	/vəˈlɒsəti/	скорость, արագություն
Volume, n	/ˈvɒljuːm/	количество, объем, ծավալ
Voluntary, adj	/ˈvɒləntri/	благотворительный, неоплачиваемый, կամայական
Weight, n	/weɪt/	вес, քաշ, կշիռ

Ex. II. Answer the following questions on the text:

1. What is a unit?
2. What are the three fundamental units?

3. What systems of measurement are widely in use all over the world?
4. How meter was originally defined?
5. Where is it kept?
6. What standard unit is used for measuring area, volume, mass, time?

Ex. III. Give English equivalents for the following words and expressions:

Меры измерения/չափման միավորներ, физические единицы/ֆիզիկական միավորներ, скорость/արագություն, плотность/խտություն, длина/երկարություն, вывести/դուրս բերել, метрическая систем/մետրային համակարգ, стандартный метр/ ստանդարտ մետր, международное соглашение/միջազգային համաձայնագիր, кубический/խորանարդ, сплав/խառնուրդ, слиток/ձող, штрих/շտրիխ:

Ex. IV. Give Russian/Armenian equivalents for the following words and expressions:

To deal with, measurements, physical quantity, length, velocity, mole, candle, area, volume, to time, to derive from, mass, fundamental units, equator, conversion, scratch, platinum alloy bar, square metre, cubic metre, ampere, decimal, dimension, in terms of, to combine mathematically, electric current.

Ex. V. Choose the appropriate option and fill in the gaps:

1. Unit is a … adopted as a standard of measurement. (quality/quantity)
2. Velocity is length … by time. (multiplied/divided)
3. The second is a unit for measuring time in … (MKS/ all systems)
4. … is a mathematical operation. (dimension/division)
5. The square metre is an MKS unit of (area/volume)
6. Foot is a unit of … in the English system of measurement. (area/length)

Ex.VI. Complete the following table with verbs and nouns to describe mathematical processes:

Sign	**Noun**	**Verb**
+		
-		
x		
÷		
=		

Ex.VII. Match the mathematical operations with the words from the column:

1. Cube root	a) $\frac{2}{4}$
2. Fraction	b) $\sqrt[2]{}$
3. Linear equation	c) $y = 4x + 6$
4. Square root	d) $\sqrt[3]{}$
5. Quadratic equation	e) $x^2 - 6x + 9 = 0$

Ex. VIII. Speak out the following scientific terms, signs:

b^2 a' 10^7 $a \leq b$ $a \geq b$ $a + b = c$ $a - b = c$

a_1 10^{-11} $a \neq b$ $\{\}$ $()$ $a \times b = c$ $a \div b = c$

Ex. IX. Fill in the gaps with proper words and expressions: ***(light year, speed, time, distance, metric, division, 499.0 seconds)***

1. Light covers the distance from the Sun to the Earth in …
2. Km/hr is a unit of … in the SI international … system.
3. We define speed as … divided by …
4. The word 'per' indicates …
5. We use lt. yr. while speaking of … .

Ex. X. Fill in the sentences with the given international terms:

Theorem, mechanics, energy, vector, scalar, gravitation, plus, minus, cube, harmonic, oxides.

1……..motion is a component of circular motion.

2. Newton's law of universal ………states that every object attracts every other object.

3. Quantities which have only magnitude are called…….

4. Quantities which have both magnitude and direction are called…….

5. Positive charges are denoted with the sign + (…), and negative with the sign – (….).

6. There are different types of ………; kinetic, elastic, heat, chemical, electric.

7. A…….. is a statement that can be demonstrated to be true.

8. There are countless particles in a …….. millimeter of gas.

9. ……….is a branch of physical science that deals with energy and forces and their effect on bodies.

10……..of metals when found naturally are called ores.

READING 2.

Metric Prefixes

Physical objects or phenomena may vary widely. For example, the size of objects varies from something very small (like an atom) to something very large (like a star). Yet the standard metric unit of length is the meter. So, the metric system includes many prefixes that can be attached to a unit. Each prefix is based on factors of 10 (10, 100, 1,000, etc., as well as 0.1, 0.01, 0.001, etc.). The metric system is convenient because conversions between metric units can be done simply by moving the decimal place of a number. This is because the metric prefixes are sequential powers of 10. There are 100 centimeters in a meter, 1000 meters in a kilometer, and so on. In nonmetric systems, such as U.S. customary units, the relationships are less simple – there are 12 inches in a foot, 5,280 feet in a mile, 4 quarts in a gallon, and so on. Another advantage of the metric system is that the same unit can be used over extremely large ranges of values simply by switching to the most-appropriate metric prefix. For example, distances in meters are suitable for building construction, but kilometers are used to describe road construction. Therefore, with the metric system, there is no need to invent new units when measuring very small or very large objects—you just have to move the decimal point (and use the appropriate prefix). International system of unit is the name adopted by the Eleventh General Conference on Weights and Measures, held in Paris in 1960, for a universal, unified, self-consistent system of measurement units based on the MKS (meter-kilogram-second) system. The international system is commonly referred to throughout the world as SI, after the initials of System International. The Metric Conversion Act of 1975 commits the United States to the increasing use of the metric system of measurement, further defining metric system as the International System of Units as interpreted or modified for the United States. At the 1960 conference, standards were defined for six base units; a seventh base unit, the mole, was added in 1971.

Table 1. gives the metric prefixes and symbols used to denote the different various factors of 10 in the metric system.

Prefix	Symbol	Value	Example Name	Example Symbol	Example Value	Example Description
exa	E	10^{18}	Exameter	Em	10^{18}m	Distance light travels in a century
peta	P	10^{15}	Petasecond	Ps	10^{15}s	30 million years
tera	T	10^{12}	Terawatt	TW	10^{12}W	Powerful laser output
giga	G	10^{9}	Gigahertz	GHz	10^{9}Hz	A microwave frequency
mega	M	10^{6}	Megacurie	MCi	10^{6}Ci	High radioactivity
kilo	k	10^{3}	Kilometer	km	10^{3}m	About 6/10 mile
hector	h	10^{2}	Hectoliter	hL	10^{2}L	26 gallons
deka	da	10^{1}	Dekagram	dag	10^{1}g	Teaspoon of butter
-	-	10^{0} (=1)				
deci	d	10^{-1}	Deciliter	dL	10^{-1}L	Less than half a soda
centi	c	10^{-2}	Centimeter	Cm	10^{-2}m	Fingertip thickness
milli	m	10^{-3}	Millimeter	Mm	10^{-3}m	Flea at its shoulder
micro	µ	10^{-6}	Micrometer	µm	10^{-6} m	Detail in microscope
nano	n	10^{-9}	Nanogram	Ng	10^{-9}g	Small speck of dust
pico	p	10^{-12}	Picofarad	pF	10^{-12}F	Small capacitor in radio

femto	f	10^{-15}	Femtometer	Fm	10^{-15}m	Size of a proton
atto	a	10^{-18}	Attosecond	as	10^{-18}s	Time light takes to cross an atom

Ex. I. Answer the following questions on the text:

1. When was the Metric Conversion Act adopted?
2. How many basic units were initially defined?
3. What was the last base unit added to the SI system?
4. Are the names of all units the same in all languages?

Ex. II. Render the text “Units of Measurements”:

SPEAKING

Make a short presentation on the following topic:
“The contemporary metric systems in physics”

1. Are there any safety rules you have to keep to when you work in a lab?

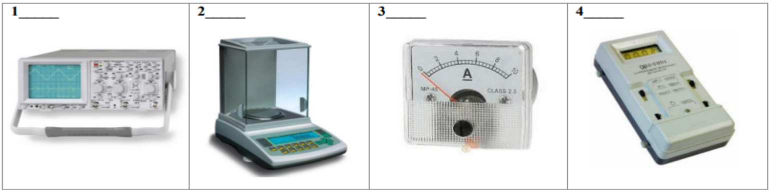
2. Work in small groups. Read some of the lab safety instructions. Discuss and sort out the things you should do and shouldn’t do when working in the lab under these headings.

Do's | **Don'ts**

Do's	Don'ts

- follow all written and verbal instructions carefully;
- read all procedures thoroughly before entering the laboratory;
- be sure that the current is turned off before making adjustments in the circuit;
- report any accident (spill, breakage, etc.) or injury (cut, burn, etc.) to the teacher immediately;
- fool around in the lab;
- look into a container that is being heated;
- use equipment with care for the purpose for which it is intended;
- use laboratory glassware as containers for food or beverages;
- set up and use the equipment as directed by your teacher;
- interfere with the laboratory experiments of others;
- wear goggles when using any type of projectile;
- place hot apparatus directly on the laboratory desk if there is no an insulated pad;
- get the instructor's permission before you try something original;
- ask the instructor to check all electrical circuits before you turn on the power.

Ex. IV. Label the pictures and give definitions to the devices:



a) ammeter   b) oscilloscope   c) dosimeter   d) electronic balance

- Do you use these instruments at your physics lab classes?
- What other instruments and devices do you use in your university physics laboratories?

WRITING

Ex. V. Search the Internet to find information about one of the most advanced devices or tools used in modern physics: Write a brief description of this tool/device. Make sure to include the information about its parts and components, operation and application. Follow the guidelines to help you.

- The way it operates
- Its size, parts and components
- Areas of its application

Ex.VI. Here are some of the instruments used in physics. Give their Russian/Armenian equivalents and check if you know their functions:

Accelerometer	an electromechanical device used to measure acceleration forces
Diffractometer	an instrument for studying atomic crystal structure by measuring the angles at which x-rays, neutrons, or electrons are diffracted by matter
Electronic capacitor	a device that can be charged up with electrical energy, store it and then release it
Laser	a device that produces coherent light by stimulated emission of radiation
Manometer	an instrument that uses a column of liquid to measure pressure
Multimeter	an electronic measuring instrument for measuring voltage, current and resistance
Mass spectrometer	a device used to measure the mass of atoms or molecules
Photometer	an instrument for measuring light intensity or optical properties of solutions or surfaces
Refractometer	an instrument used to measure refraction of light
Spectrometer	an instrument for measuring properties of light over a specific portion of the electromagnetic spectrum, typically used in spectroscopic analysis to identify materials
Thermocouple	a sensor for measuring temperature in wide temperature ranges
Viscometer	an instrument used to measure the viscosity of a fluid
Voltmeter	an instrument used for measuring electrical potential difference between two points in an electric circuit

Grammar exercises

1. Complete the sentences and the text. Use Past Simple or Past Continuous:

1. When I (do) my laboratory experiment, I (break) a bulb.
2. He (drink) some juice and then he (eat) a few chips.
3. I (have) dinner when I suddenly (hear) some noise.
4. When Mr.Johnson (work) in the garden, an old friend (pass) by to see him.

5. When it (start) to rain, our dog (want) to come inside.
6. When Jane (do) a language course in Ireland,
she (visit) Blarney Castle.
7. When I (be) on my way home, I (see) an accident.
8. I (not / understand) what they (talk) about.

2 Sometimes I hate computers! Once, when I (try) to do my English homework on my laptop, the battery (run out). I (lie) on my bed and I was listening to music on Spotify. It helps me to concentrate. I also (chat) to my friend Sam on Facebook. OK, so I (not concentrate) very hard on my homework and I (forget) to plug in my laptop! I didn't notice that the battery was getting low. I was just finishing the essay when the screen (go) black. I (lose) everything. I (scream) in frustration. My dad (come) running into my bedroom. I almost (cry) so he (give) me his laptop. I (try) to remember everything in my essay – it (be) quite difficult especially because Daniel was sending me lots of funny videos. Anyway, while I was watching one, the WiFi stopped working. In the end it was probably better because I (manage) to finish the essay.

Ex. VII. Translate the sentences into Russian/Armenian:

1. Unless various units of the MKS system had possessed simple and logical relationships, they wouldn't have been basis of the SI Units.
2. If the standard meter of the world had been made on a gold or silver alloy bar, it shouldn't have been so accurate.

3. If any law of physics were wrong, this should cause a change in our standards of length and time.
4. Unless the scientists had developed atomic clocks, we wouldn't have had so accurate standard of time.
5. Unless the accuracy of the optical clock developed by the Soviet scientists had been still greater, the atomic clock would have been the most accurate now.

LISTENING

Scan the QR code, watch the video and answer the questions on the topic:

1. What does French Revolution have to do with the metric system?
2. Which system replaced the Roman numerals and fractions in the Middle Ages?
3. Which country is among the three ones that preserved their own metric system?
4. Is the speed of light a universal constant?

Enjoy yourself

Professor: If you were in Africa and saw a lion coming, what steps would you take?

Student: The longest steps I could.

UNIT III.

Ex. I. Read the text paying attention to the new vocabulary:

The energy of the mind is the essence of life
Aristotle

ENERGY

There is a law governing all natural phenomena. There is no exception to this law-it is exact so far as we know. The law is called the conservation of energy. It states that there is a certain quantity, which we call energy that does not change in manifold changes which nature undergoes. Energy has a large number of different forms, and there is a formula for each one. These are: potential energy, kinetic energy, waste energy, elastic energy, electrical energy, chemical energy, radiant energy, nuclear energy.

Let's consider a pendulum to illustrate one of the types of energy. If we pull the mass aside and release it, it swings back and forth. In its motion, it loses height in going from either end to the center. Where does the potential energy go? Gravitational energy disappears when it is down at the bottom: nevertheless, it will climb up again. The gravitational energy must have gone into another form. Evidently it is by virtue of its motion that it is able to climb up again, so we have the conversion of gravitational energy into some other form when it reaches the bottom. There are many other forms of energy. There is electrical energy, which has to do with pushing and pulling by electric charges. There is radiant energy, the energy of light, which we know is a form of electrical energy because light can be represented as wigglings of the electromagnetic field. There is chemical energy, the energy which is released in chemical reactions. Our modern understanding is that chemical energy has two parts, kinetic energy of the electrons inside the atoms, so part of it is kinetic and electrical energy of interaction of the electrons and the protons- the rest of it is electrical. Next we come to nuclear energy, the energy which is involved with the arrangement of particles inside the nucleus.

It is obvious that the law of conservation of energy is enormously useful in making analyses and is very important.

Study the basic vocabulary

Word	Pronunciation	Translation
Aim, n	/eɪm/	цель, նպատակ
Attempt, n	/əˈtempt/	попытка, փորձ
Challenging, adj	/ˈtʃælɪndʒɪŋ/	трудный, требующий напряжения, մարտահրավեր
Conception, n	/kənˈsepʃn/	представление, понимание, երևույթ
Convert, v	/kənˈvɜːt/	переводить, переобо-рудовать, փոխա-կերպել
Conversion, n	/kənˈvɜːʃn/	переход (к чему-либо), անցում

Conservation, n	/ˌkɒnsəˈveɪʃn/	сохранение, պահպանում
Consideration, n	/kənˌsɪdəˈreɪʃn/	рассмотрение, обдумывание, դիտարկում
Estimate, v	/ˈestɪmeɪt/	подсчитывать, оценивать, գնահատել
Equivalent, adj	/ɪˈkwɪvələnt/	равноценный, соответствующий, համապատասխան
Force, n	/fɔːs/	сила, воздействие, ուժ
Gain, v	/ɡeɪn/	получать, приобретать, ձեռք բերել
Heat, n	/hiːt/	жара, тепло, ջերմություն
Mutual, adj	/ˈmjuːtʃuəl/	взаимный, փոխադարձ
Nuclear, adj	/ˈnjuːkliə(r)/	ядерный, միջուկային
Pendulum, n	/ˈpendʒələm/	маятник, ճոճանակ
Propose, v	/prəˈpəʊz/	предлагать, առաջարկել
Radiant, adj	/ˈreɪdiənt/	сияющий, лучезарный, լուսարձակող
Release, v	/rɪˈliːs/	освобождать, արձակել
Remain, v	/rɪˈmeɪn/	Оставаться , մնալ
Sum, n	/sʌm/	сумма, գումար
Strike, v	/straɪk/	ударять, стукнуть, հարվածել

Tension, n	/ˈtenʃn/	напряженность, լարում
Undergo, v	/ˌʌndəˈgəʊ/	переносить, подвергаться, ենթարկվել

Ex. II. Answer the questions on the text.

1. What law governs all natural phenomena?
2. What does the law of conservation of energy state?
3. Illustrate the existence of energy by examples.
4. What energy is released in chemical reactions?
5. What fuel is the main source of energy?
6. Can we get energy from uranium?
7. Can we get energy from hydrogen?
8. Is solar energy used nowadays?

Read the text "Types of Energies" and think of other examples of energies in nature:

Types of Energies

Potential Energy

Potential energy is stored energy. It is energy that is stored in a body as a result of the body's having been lifted, compressed, stretched, twisted, or bent. Thus, bodies have potential energy if they are where they could fall, slide, or roll. Therefore, anything that you hold in your hand has potential energy because it is in a position to fall. A skier on a mountain-side has potential energy because he is in a position to slide. A car parked at the top of an incline likewise has potential energy. It is in a position to roll to the bottom. In all these cases the objects have energy because of gravity.

When any of these bodies has reached level ground, however, it no longer has potential energy due to its position. The potential energy that it had was changed on the way down to energy of motion and heat energy. Likewise, when objects that have been compressed, stretched, twisted, or bent return to their normal conditions, they no longer possess potential energy. The potential energy that they had as a result of their strained conditions was changed to energy of motion and heat as they resumed their normal shapes. The chemical energy stored in substances such as foods, fuels, and explosives is also potential energy. The potential energy thus stored can be changed by burning or by other means to light, heat, or other forms of energy.

Kinetic Energy

Kinetic energy is the energy in motion. Any moving body has kinetic energy. Many bodies have both potential and kinetic energy at the same time. Thus, when a basketball strikes the floor, the air inside it is further compressed. This compression gives the ball potential energy. But while the ball is rising from the floor in a bounce, its potential energy is being changed into kinetic energy. By the time it has reached the top of its bounce, all its kinetic energy has been changed to potential energy of position. Then, while it is falling again, this potential energy is being changed to kinetic energy.

Wasted energy

Any form of energy can be changed into other forms without loss. Part of it, however, is always likely to be changed into one or more forms that at the time we cannot use. For all practical purposes that energy is wasted. Sometimes it does harm. To illustrate, the gasoline that is put into a car is potential energy, and so also are the chemicals in the battery. As the car runs, part of the potential energy of the gasoline and the battery is changed to useful kinetic energy, to light, and to current electricity. But much of it is changed, also, to heat energy. This change takes place in the engine. In all the moving parts, in the wiring, and in the lamps. As much heat is sometimes thus produced as would be needed for heating several rooms. Most of this heat is wasted energy because it serves no useful purpose. Moreover, if enough of it were not continuously removed, it would quickly ruin the engine, the battery, and the wiring. No doubt you can think of other damage that it would do.

Ex. III. Find the equivalents:

to calculate	**в некоторой степени/ինչ-որ չափով**
to conserve	**рассматривать/դիտարկել**
to release	**благодаря чему-либо/շնորհիվ**

possible	**точный/ճշգրիտ**
by virtue of smth	**освобождать/արձակել**
to a certain extent	**возможный/հավանական**
exact	**сохранять/պահպանել**
to consider	**вычислять/հաշվարկել**

Ex. IV. Give Russian/Armenian equivalents for the following words and expressions:

Conservation, manifold, to undergo changes, formula, gravitational force, kinetic, chemical energy, radiant, nuclear power, mass, pendulum, to release, to swing, potential energy, pulling and pushing, wigglings, electric charge, interaction, particles, nucleus, considerations, strained conditions, to resume, due to, to do damage, wasted energy, to bounce off, loss of energy, to twist, to bend.

Ex. V. Give English equivalents for the following words and expressions:

Частица/մասնիկ, подвергаться/ենթարկվել, количество/քանակ, маятник/ճոճանակ, потеря энергии/էներգիայի կորուստ, пружина/զսպանակ, условие/պայման, конвертировать/փոխակերպել, движение/շարժում, толкать/հրել, тянуть/ձգել, заряд/լիցք, включать в себя/ներառել, модификация/փոփոխություն, освобождать/արձակել, исчезать/անհետանալ, сохранение/պահպանում:

Ex.VI. Make up new words using prefixes and suffixes:

eliminate	______________	push	______________
calculate	______________	experiment	______________
reduce	______________	connect	______________
arrange	______________	exist	______________
observe	______________	value	______________

nature	______________
smooth	______________
centre	______________
rotate	______________
attract	______________

-al	-or	-en	-ing	-ment	(t)ion	-ance	-ence	-able

Ex.VII. Arrange the following words according to the parts of speech they belong to:

Noun	Verb	Adjective	Adverb

Physics-physicist-physical, nature-natural, experiment-experimental, theory-theoretical, definite-definitely, accurate-accurately, primary-primarily, central-centrally, positive-positively, negative-negatively, to observe-observation, to describe-description, to relate-relation, to transform-

transformation, to investigate-investigation, to attract-attraction, to interact-interaction, to connect-disconnect, period-periodic, to produce-production-productive, gravitation-gravitational, to add-addition-additional, to convert-conversion, to conserve- conservation, to arrange-arrangement, to exist- existence.

Ex. VIII. Match the beginnings and endings of the sentences:

Beginnings	Endings
1.Energy is the ability	a)distance times effort
2.Nuclear fission is the splitting	b)two or more small nuclei to produce energy
3.Nuclear fusion involves combining	c) to do work
4.Energy equals	d) that increases the effect of a force
5.A machine is any device	e) of the nucleus of an atom
6.The ray that bounces off the surface is	f) at a speed of 3.0*10^8 m/s
7.When light reflects from a surface the incoming ray	g) the umbra
8.The very dark region of a shadow is called	h) and so create a shadow
9.Light travels in a vacuum	i) is called the incidents ray
10.Light can't pass through opaque objects	j) called the reflected ray

Ex. IX. Finish the sentences based on the information obtained from the text:

1. The law of conservation of energy states that….
2. The forms of energy are….
3. The energy never disappears, instead it….
4. Electrical energy has to do with….
5. Chemical energy has two parts ….
6. Nuclear energy is involved with ….
7. Law of conservation of energy is useful in ….

READING 2.

The Law of Conservation of Energy

Heat is the most active, powerful and mysterious phenomenon of Nature. Once it was a really challenging problem to physicists. The first to estimate the mechanical equivalent of heat was Robert Mayer (1842). Soon it was also proposed by Joule and later by von Helmholtz. Mayer was led to the conception by general philosophical considerations of a cosmical kind. He was struck by the analogy between the energy gained by bodies falling under gravity and the heat given off by compressed gases. Joule was led to the idea first by experiments aimed at finding out how far the new electric motor could become a practical source of power. Helmholtz in

1847, by an attempt to generalize the Newtonian conception of motion to that of a large number of bodies acting under mutual attraction, showed that the sum of force and tension, what we would now call kinetic and potential energy, remained the same. This is the principle of conservation of energy in its most formal sense.

Ex. X. Translate the following sentences from Russian/Armenian into English:

1. Кинетческая энергия зависит от массы и скорости движения тела.
Կինետիկ էներգիան կախված է մարմնի զանգվածից և նրա շարժման արագությունից:
2. Масса тела не меняется при переходе от одной инерциальной системы отсчета к другой.
Մարմնի զանգվածը չի փոխվում մեկ իներցիալ համակարգից մյուսին անցնելիս:
3. Потенциальная энергия присуща всем телам, которые обладают потенциальной способностью совершать работу.
Պոտենցիալ էներգիան բնորոշ է բոլոր մարմիններին, որոնք ունեն աշխատանք կատարելու ունակություն:
4. Во всех явлениях, происходящих в природе, энергия не возникает и не исчезает.
Բոլոր երևույթներում, որոնք տեղի են ունենում բնության մեջ, էներգիան չի առաջանում և չի անհետանում:
5. Сила тяжести пропорциональна массе тела, на которое она действует.

Ծանրության ուժը ուղիղ համեմատական է մարմնի զանգվածին որի վրա այն ազդում է:

SPEAKING

Make a short presentation on the following topic "Alternative means of energy – Solar Energy".

Grammar exercises

Modify Infinitive Constructions using relative pronouns (that, which, what…):

1. We know an alternating current to be continually changing.
2. Newton considered light to consist of very tiny particles-corpuscles.
3. We shall consider the core to be inert, and we will allow the particles to populate all states of the open shell.
4. The measurements are translated into color pictures to show the distribution of the particles over the test area.
5. Lelyuk found the lubricating qualities of certain oils to increase with dirtiness under extreme friction conditions.

Key: 1.We know that an alternating current is continually changing.

LISTENING

Scan the QR code, watch the video and answer the questions on the topic.

1. What does renewable energy need?
2. How much space do we need for nuclear power, solar power, wind power?
3. Where do we get electricity according to the 2020 data?
4. Do nuclear plants emit greenhouse gases?

Enjoy yourself

In one of his lectures a well-known mathematician said: “Every person has a certain horizon. When that horizon narrows down and becomes infinitely small, it turns into a point.”

That is when a person says: “This is my point of view.”

UNIT IV.

Ex. I. Read the text paying attention to the new vocabulary:

I can calculate the motion of heavenly
bodies but not the madness of people
Isaac Newton

NEWTON'S LAWS OF DYNAMICS

The discovery of the laws of dynamics, or the laws of motion, was a dramatic moment in the history of science. Galileo made a great advance in the understanding of motion when he discovered the principle of inertia: if an object is left alone, is not disturbed, it continues to move with a constant velocity in a straight line if it was originally moving, or it continues to stand still if it was just standing still.

But how does an object change its speed if something is affecting it? That is the contribution of Newton. Newton wrote down three laws. The First Law is a mere restatement of the Galileon principle of inertia. The Second Law gave a specific way of determining how the velocity changes under different influences called forces. The Third Law describes the forces to some extent.

Newton’s first law of motion states the following:

1. A body at rest tends to remain at rest.

2. A body in motion tends to remain in motion at a constant velocity unless acted on by a net external force.

(Recall that constant velocity means that the body moves in a straight line and at a constant speed.) At first glance, this law may seem to contradict your everyday experience. You have probably noticed that a moving object will usually slow down and stop unless some effort is made to keep it moving. The key to understanding why, for example, a sliding box slows down (seemingly on its own) is to first understand that a net external force acts on the box to make the box slow down. Without this net external force, the box would continue to slide at a constant velocity (as stated in Newton's first law of motion). What force acts on the box to slow it down? This force is called friction. Friction is an external force that acts opposite to the direction of motion. Think of friction as a resistance to motion that slows things down. Consider an air hockey table. When the air is turned off, the puck slides only a short distance before friction slows it to a stop. However, when the air is turned on, it lifts the puck slightly, so the puck experiences very little friction as it moves over the surface. With friction almost eliminated, the puck glides along with very little change in speed. On a frictionless surface, the puck would experience no net external force (ignoring air resistance, which is also a form of friction). Additionally, if we know enough about friction, we can accurately predict how quickly objects will slow down.

The Second Law states that the motion of an object is changed by forces in this way: the time-rate-of-change of a quantity called momentum is proportional to the force.

So, momentum is not the same as velocity. Weight and inertia are proportional, and on the earth's surface are often taken to be numerically equal. We must use the term mass as a quantitative measure of inertia, and we may measure mass, for example, by swinging as object in a circle at a certain speed and measuring how much we need to keep it in a circle. In this way we find a certain quantity of mass for an object. Now the momentum of an object is a product of two parts: its mass and its velocity. Thus Newton's Second Law may be written mathematically in this way:

$\mathbf{F_{net} = ma}$ where $\mathbf{F_{net}}$ (or $\sum F$) is the net external force, **m** is the mass of the system, and **a** is the acceleration. Note that F_{net} and $\sum F$ are the same because the net external force is the sum of all the external forces acting on the system.

First, what do we mean by a change in motion? A change in motion is simply a change in velocity: the speed of an object can become slower or faster, the direction in which the object is moving can change, or both of these variables may change. A change in velocity means, by definition, that an acceleration has occurred. Newton's first law says that only a nonzero net external force can cause a change in motion, so a net external force must cause an acceleration. Note that acceleration can refer to slowing down or to speeding up. Acceleration can also refer to a change in the direction of motion with no change in speed, because acceleration is the change in velocity divided by the time it takes for that change to occur, and velocity is defined by speed and direction. From the equation $\mathbf{F_{net} = ma}$, we see that force is directly proportional to both mass and acceleration, which makes sense. To accelerate two objects from rest to the same velocity, you would expect more force to be required to accelerate the more massive object.

It is important to remember that weight and mass are very different, although they are closely related. Mass is the quantity of matter (how much stuff) in an object and does not vary, but weight is the gravitational force on an object and is proportional to the force of gravity. It is easy to confuse the two, because our experience is confined to Earth, and the weight of an object is essentially the same no matter where you are on Earth. Adding to the confusion, the terms mass and weight are often used interchangeably in everyday language; for example, our medical records often show our weight in kilograms, but never in the correct unit of newtons.

Study the basic vocabulary

Word	**Pronunciation**	**Translation**
Constant, adj	/ˈkɒnstənt/	постоянный, հաստատուն
Force, n	/fɔːs/	сила, воздействие, ուժ
Friction, n	/ˈfrɪk.ʃən/	трение, շփում
Momentum, n	/məˈmentəm/	движущая сила, մոմենտ
Oscillator, n	/ˈɒsɪleɪtə(r)/	осциллятор, պտուտակ
Principle of inertia		принцип инерции, իներցիայի օրենք
Predict, v	/prɪˈdɪkt/	предсказывать, կանխատեսել

Product, n	/ˈprɒdʌkt/	произведение (математическое) բազմապատկում
Puck, n	/pʌk/	шайба, տափօղակ
Slide, v	/slaɪd/	скользить, սահել
Still, adj	/stɪl/	спокойный, тихий, հանդարտ
Time-rate-of-change of a quantity		скорость изменения величины со временем, արագության փոփոխությունը կախված ժամանակից

Ex. II. Answer the following questions on the text "Newton's Laws of Dynamics":

1. What did Galileo discover?
2. What does the First Law state?
3. What does the Second Law state?
4. Is momentum the same as velocity?
5. What is the momentum of an object?
6. Define speed, mass, acceleration, force.
7. Is velocity the same as speed?

Ex. III. Give English equivalents for the following words and expressions:

Законы динамики/ դինամիկայի օրենքներ, законы движения/շարժման օրենքներ, движение планет/մոլորակների շարժում, принцип инерции/իներցիայի սկզբունք, постоянная скорость/հաստատուն արագություն, влиять/ազդել, замедлять/դանդաղել, определять /սահմանել, точный/ ճշգրիտ, пропорциональный/համաչափ, масса тела/մարմնի զանգված, скорость тела/մարմնի արագություն, величина импульса/իմպուլսի մեծություն, изменение направления /ուղղության փոփոխություն:

Ex. IV. Give Russian/Armenian equivalents for the following words and expressions:

To seek, to act on smth, in principle, simple, complicated, objects at rest, in the same way, momentum, to work out solution, in practice, to appreciate, to suppose, to fail, countless, property, complete, velocity, to exert, time-rate-of-change, proportional to, still, the force of gravity, to use interchangeably, weight of an object, frictionless surface, external force, slow down, speed up.

Ex. V. Make necessary word-formation changes and fill in the gaps:
(scientific, gravity, mathematics, mechanics, rotate, planet, physics, emit, move)

1. He studies mathematics. He is meant to be ….
2. His field is science. He is a ….
3.…. generally are interested in the root or ultimate causes of natural phenomena.

4. Luminescence is the … of light from a body from any cause other than high temperature.
5. The … which will be calculated can be explained in terms of acceleration.
6. The discoveries mention the laws of … in general and …in particular.
7. The motion of bodies may be divided into three classes: translation, … and vibration.
8. The laws of … motion were developed by Kepler.

Ex. VI. Make up sentences with the given words:

1. four/can/Matter/exist/states/in.
2. based/on/physical/Every/ law/experiment/is.
3. combination/ A/ atoms/molecule/is/the/of.
4. deals/ relation/ matter/Physics/with/and/the/energy/between.
5. What/study/physics/ does/nuclear?
6. easily/A/object/ moves/light.
7. must/ We/ define/accurately/this/quantity.
8. velocity/from/We/ speed/ distinguish.
9. less/A/ heavier/ moves/ rapidly/object.
10. object/changes/A/its/direction/moving.

Ex. VII. Finish the sentences based on the information obtained from the text:

1. Newton discovered…
2. Galileo made a great advance in….
3. If an object is left alone …..

4. The Second Law states that …..
5. We use the term mass as…..

READING 2.

Newton's Laws of Dynamics
(Continued)

Newton's third law of motion states that whenever a first object exerts a force on a second object, the first object experiences a force equal in magnitude but opposite in direction to the force that it exerts. Newton's third law of motion tells us that forces always occur in pairs, and one object cannot exert a force on another without experiencing the same strength force in return. We sometimes refer to these force pairs as action-reaction pairs, where the force exerted is the action, and the force experienced in return is the reaction (although which is which depends on your point of view). Newton's third law is useful for figuring out which forces are external to a system. Recall that identifying external forces is important when setting up a problem, because the external forces must be added together to find the net force. We can see Newton's third law at work by looking at the following examples below.

As a teacher paces in front of a whiteboard, he exerts a force backward on the floor. The floor exerts a reaction force in the forward direction on the teacher that causes him to accelerate forward. Similarly, a car accelerates because the ground pushes forward on the car's wheels in reaction to the car's wheels pushing backward on the ground. You can see evidence of the wheels pushing backward when tires spin on a gravel road and throw rocks backward. Another example is the force of a baseball as it makes contact with the bat. Helicopters create lift by pushing air down, creating an upward reaction force. Birds fly by exerting force on air in the direction opposite that in which they wish to fly. For example, the wings of a bird force air downward and backward in order to get lift and move forward. An octopus propels itself forward in the water by ejecting water backward through a funnel in its body, which is similar to how a jet ski is propelled. In these examples, the octopus or jet ski push the water backward, and the water, in turn, pushes the octopus or jet ski forward.

Forces are classified and given names based on their source, how they are transmitted, or their effects. Applying Newton's third law of motion will allow us to explore three more forces: the normal force, tension, and thrust. The gravitational force (or weight) acts on objects at all times and everywhere on Earth. We know from Newton's second law that a net force produces an acceleration; so, why is everything not in a constant state of freefall toward the center of Earth? The answer is the normal force. The normal force is the force that a surface applies to an object to support the weight of that object; it acts perpendicular to the surface upon which the object rests. If an object on a flat surface is not accelerating, the net external force is zero, and the normal force has the same magnitude as the weight of the system but acts in the opposite direction. In equation form, we write that **N=mg**

Note that this equation is only true for a horizontal surface.

Another example of Newton's third law in action is thrust. Rockets move forward by expelling gas backward at a high velocity. This means that the rocket exerts a large force backward on the gas in the rocket combustion chamber, and the gas, in turn, exerts a large force forward on the rocket in response. This reaction force is called thrust.

In our discussion of Newton's laws it was explained that these laws are a kind of program that says "Pay attention to the forces", and that Newton told us only two things about the nature of forces. In the case of very complicated forces between atoms, he was not aware of the right laws for the forces; however, he discovered one rule, one general property of forces, which is expresses in the Third Law, and that is the total knowledge that Newton had about the nature of forces-the law of gravitation and this principle, but no other details.

This principle is that action equals reaction. What is meant is something of this kind: suppose we have two small bodies, say particles, and suppose that the first one exerts a force on the second one, pushing it with a certain force. Then, simultaneously, according to Newton's Third Law, the second particle will push on the first with an equal force, in the opposite direction; furthermore, these forces effectively act in the same line.

Science teacher: “Explain Newton law of motion”
Student: “Sir, I only know the last line of it”
Science teacher: “Okay, tell the last line”
Student: “…and this is called Newton’s law of motion”

Study the basic vocabulary

Word	Pronunciation	Translation
Cause, v	/kɔːz/	причинять, вызывать պատճառել
Challenge, v	/ˈʧælɪndʒ/	бросать вызов, оспаривать, մարտահրավեր նետել
Combustion chamber		камера сгорания այրման խցիկ
Cosine, n	/ˈkəʊsaɪn/	косинус, կոսինուս
Complicated, adj	/ˈkɒmplɪkeɪtɪd/	сложный, խճճված
Consequence, n	/ˈkɒnsɪkwəns/	последствие, հետևանք
Countless, adj	/ˈkaʊntləs/	бесчисленный, անթիվ
Determine, v	/dɪˈtɜːmɪn/	устанавливать, определять, սահմանել

Displacement, n	/dɪsˈpleɪsmənt/	вытеснение перемещение, տեղափոխություն
Eject, v	/ɪˈdʒekt/	выбрасывать, արտանետել
Enormous, adj	/ɪˈnɔːməs/	огромный, ահռելի
Exert, v	/ɪgˈzɜːt/	проявлять, влиять, գործադրել, կիրառել
Experience, v	/ɪkˈspɪəriəns/	испытываать, զգալ, տանել
Expel, v	/ɪkˈspel/	исключать, выгонять, հեռացնել, դուրս մղել
Evidence, n	/ˈevɪdəns/	доказательство, данные, փաստ
Flow, n	/fləʊ/	струя, поток, հոսք
Fluid, n	/ˈfluːɪd/	жидкость, հեղուկ
Funnel, n	/ˈfʌn.əl/	воронка, ձագար
Furthermore, adv	/ˌfɜːðəˈmɔː(r)/	кроме того, более того, ավելին, բացի այդ
Gravel, n	/ˈgræv.əl/	Гравий, անրախիճ
Globular cluster		шаровое скопление, գնդաձև կլաստեր/բույլ
Jet ski		гидроцикл, ջրային արագընթաց մոտոցիկլետ

Net force		равнодействуюшая сила, համազոր ուժ
Occur, v	/əˈkɜː(r)/	происходить, պատահել
Pace, v	/peɪs/	расхаживать, քայլել
Pattern, n	/ˈpætn/	модель, образец, նմուշ
Propel, v	/prəˈpel/	Продвигать, մղել
Recall, v	/rɪˈkɔːl/	вспоминать, напоминать, հիշեցնել, հիշել
Ridiculous, adj	/rɪˈdɪkjələs/	нелепый, անհեթեթ
Seek, v	/siːk/	искать, փնտրել
Simultaneously, adv	/sɪm.əlˈteɪ.ni.əsli/	одновременно, միաժամանակ
Suppose, v	/səˈpəʊz/	предполагать, ենթադրել
Tension, n	/ˈtenʃn/	напряжение, давление, լարում
Thrust, n	/θrʌst/	толчок, удар, մղում, հրում

Ex. VII. Translate the following sentences into Russian/Armenian:

1. If an object is left alone, is not disturbed, it continues to move with a constant velocity in a straight line if it was originally moving.

2. The First Law is a mere restatement of the Galileon principle of inertia.
3. The Second Law states that the motion of an object is changed by forces in this way.
4. Weight and inertia are proportional, and on the earth's surface are often taken to be numerically equal.
5. Mass is constant, the same all the time, and that, further, when we put two objects together, their masses add.

Ex. VIII. Arrange the words given in a) and b) in pairs of synonyms:

A	B
to attempt	to invent
Valid	to try
to offer	to include
to involve	to suggest
to devise	accurate
Device	incomplete
Cause	later
to permit	reflection
Image	authentic
Exact	instrument
Rough	to allow
subsequent	reason

SPEAKING

1. Make a short presentation on the following topic.
The development of Newtonian Era throughout history.

2. Here are some idiomatic phrases that come from science and technology. Give their Russian/Armenian equivalents and use them in sentences of your own.

- ✓ **to blind someone with science** - to confuse people by using technical language that they are not likely to understand
- ✓ **It's not rocket science!** - it is easy to understand, obvious
- ✓ **to recharge one's batteries** - to rest or relax in order to get back your energy
- ✓ **(at) the cutting edge** - (at) the forefront of progress in a particular area
- ✓ **Don't push my buttons!** - is said to someone who is starting to annoy you
- ✓ **light years ahead** - you are a long way in front of others in terms of development, success, etc
- ✓ **to be on the same wavelength** - to have the same ideas and opinions about something
- ✓ **to get one's wires crossed** - to misunderstand each other, especially when making arrangements
- ✓ **a well-oiled machine** - something that functions very well
- ✓ **an acid test** - a rigorous or critical test of something

3. Read and remember some of the terms used in modern physics:

Antimatter	-	matter consisting of elementary particles which are the antiparticles of those making up normal matter, e.g. positron/electron
Beam	-	a ray of light; a group of particles traveling together along a well-defined path
Injector	-	the first section of an accelerator, where electrons are torn away from atoms and accelerated to an energy sufficient for them to be injected into the cavities of the accelerator
Lepton	-	a subatomic particle, such as an electron, muon, or neutrino, which does not take part in the strong interaction
Neutron	-	a subatomic particle of about the same mass as a proton but without an electric charge
Nucleon	-	a proton or a neutron
Nucleus	-	the central part of an atom, which makes up 99.9% of the atom's mass
Plasma	-	a very hot, gas-like state of matter
Probe	-	an object or device used to investigate the unknown
Proton	-	a positively charged particle found in the nucleus of an atom
Prototype	-	a first or preliminary model of something, esp. a machine, from which other forms are developed or copied
Quark	-	any of a number of subatomic particles carrying a fractional electric charge, postulated as building blocks of the hadrons. Quarks have not been directly observed but theoretical predictions based on their existence have been confirmed experimentally
Superconductivity	-	the flow of electric current without any resistance in certain metals at temperatures near absolute zero

Ex. IX. Translate into Russian/Armenian paying attention to the meaning of word "one":

1. **One** must use special instruments for measuring the resistance in the circuit.
2. The history of radar is a long **one**, for the underlying principle has been known to science for a long time.
3. Generally speaking, a liquid having a free surface is **one** on whose surface there is absolutely no pressure.

4. **One** can hardly proceed in any exploration without some definite objective and some idea of what **one** is likely to get.
5. Of all the senses, vision is the only **one** that can make us directly conscious of things at great distances.
6. In this presentation **one** should follow a logical rather than a historical order**.**
7. **One** should know that the electric cell is a device for converting chemical energy into electrical **one**.
8. Three-dimensional models often contain initial stresses which **one** cannot evaluate until a test is completed.
9. Lavoisier was convinced that **one** may take it for granted that in every reaction there is equal quantity of matter before and after the operation.
10. If **one** seeks to determine the influence of the winds on the surface temperature of the ocean, he must examine the condition of the surface layers in the different seasons of the year.

Ex. X. Translate the sentences into Russian/Armenian paying attention to the forms of infinitives, gerunds, passives, participle constructions and use of terms:

1. Our task is to receive new **data.**
2. The ray which strikes a surface is called the **incident ray**.
3. Before Galileo there were no **accurate** ways of measuring time.
4. Elastic energy is the formula for a **spring** when it is stretched.
5. The **lux** is a unit used to measure luminous intensity.

6. Analysis is naturally followed by **synthesis**.
7. A compressed **spring** can be released to its natural length without its performing any work.
8. Hydrogen is the lightest **substance** known.
9. **Alloys** of copper and tin historically were known as bronze.
10. Closely related to the true catalyzed reactions are **"induced reactions"**.

Ex. XI. Translate into English:

1.Как изменяется скорость тела, если на него действует какая-то сила?
Ինչպե՞ս է փոխվում մարմնի արագությունը նրա վրա ուժ կիրառելու դեպքում:
2. Ньютон сформулировал три закона движения.
Նյուտոնը սահմանել է շարժման երեք օրենք:
3. Первый закон представляет просто повторение принципа инерции Галилея.
Առաջին օրենքը Գալիլեյի կողմից սահմանված իներցիայի օրենքի կրկնությունն է:
4. Второй закон гласит, что сила, действующая на тело, равна произведению массы тела на его ускорение.
Երկրորդ օրենքը պնդում է, որ մարմնի վրա կիրառված ուժը հավասար է մարմնի զանգվածի և արագացման արտադրյալին:
5. Механическим движением тела называется изменение с течением времени его положения по отношению к другим телам.

Մարմնի մեխանիկական շարժումը դա ժամանակի ընթացքում տարածության մեջ մարմնի դիրքի փոփոխությունն է այլ մարմինների նկատմամբ:

LISTENING

Scan the QR code, watch the video and answer the questions on the topic:

1. Why does the bike move?
2. What happens when you ride your bicycle?
3. What is action and reaction?
4. How does the wheels of the bicycle spin?

Enjoy yourself

Fourteen-year-old George who helped in the grocer's wasn't a fast worker. In fact, he moved very slowly indeed. One day Mr. Jones, the grocer, called out to him:
"George, is there anything you can do fast?"
"Yes, Mr. Jones," answered George, "I get tired fast."

UNIT V.

Ex. I. Read the text paying attention to the new vocabulary:

If your hate could be turned into electricity,
it would light up the whole world
Nikola Tesla

ELECTRICITY AND MAGNETISM

If two metal spheres on insulating supports are charged with unlike electricity and connected by a metal conductor, electrons will flow from B, where they are in excess, to A where they are lacking. The flow of electrons in a conductor is called an electric current. If sphere A is continuously charged with positive electricity and sphere B with negative electricity, there will be a continuous flow of electric current in the conductor. While in motion along conductor, electrons collide with other electrons, atoms or molecules. As a result of these impacts, energy is released in the form of heat, and the motion of electrons along conductor is known as the electrical resistance of the conductor.

There are several factors that affect resistance.

1) Resistance varies with the atomic structure or nature of the conducting material. Good conducting materials such as silver, copper, and aluminium have low resistance. Cast iron

and nichrome (an alloy of iron, nickel, and copper) are examples of poorer conducting materials.

2) The resistance of most metals varies directly with temperature. The resistance of metals increases with increasing temperature, while that of liquids and carbon decreases. There are several metals, however, such as manganin, constantan, nickeline, etc., whose resistance remains practically unaffected by temperature rise.

3) The resistance of a conductor increases in direct proportion with its length. That is, temperature being constant, the resistance will be doubled if the length of the conductor is doubled.

The unit of electrical resistance is ohm. The resistance in ohms of a conductor 1 metre long and 1 mm^2 in cross-section is called resistivity and is designated by the Greek letter ρ(rho).

The resistance of a conductor can be found from the equation:

$R=\frac{pl}{S}$ where

R – Resistance of the conductor in ohms,

ρ – resistivity of the conductor, ohm-mm^2-m

l – length of the conductor in metres,

S – cross-section area of a conductor in mm^2

The change in the resistance of a conductor per ohm of the initial resistance and per degree change of temperature is termed the temperature coefficient of resistance and is designated by the letter α:

$$\alpha=\frac{Rt-Ro}{Ro(t-t0)}$$

where R_0 – initial resistance of the conductor

R_t – final resistance of the conductor

t_0 – initial temperature of the conductor

t – final temperature of the conductor

Study the basic vocabulary

Word	Pronunciation	Translation
Cancel, v	/ˈkænsl/	уничтожать, аннулировать, չեղոքացնել
Coefficient, n	/ˌkəʊɪˈfɪʃnt/	коэффициент, գործակից
Conductor, n	/kənˈdʌktə/	проводник, հաղորդիչ
Collide, v	/kəˈlaɪd/	сталкиваться, բախվել
Convey, v	/kənˈveɪ/	выражать, переда-вать, сообщать, փոխանցել
Cross-section		поперечное сечение, լայնական հատույթ
Denote, v	/dɪˈnəʊt/	обозначать, նշանակել
Electric current		электрический ток, էլեկտրական տոկ
Flow, n	/fləʊ/	струя, поток, հոսք

Influence, v	/ˈɪnfluəns/	влияние, ազդեցություն
In excess		избыток, ավելցուկ
Inversely, adv	/ˌɪnˈvɜːsli/	обратно, հակադարձ
Permanent, adj	/ˈpɜːmənənt/	постоянный, մշտական
Release, v	/rɪˈliːs/	освобождать, отпус-кать, արձակում
Precise, adj	/prɪˈsaɪs/	точный, ճշգրիտ
Remote, adj	/rɪˈməʊt/	отдаленный, дальний, հեռավոր
Repel, v	/rɪˈpel/	отклонять, отталкивать, վանել
Resistance, n	/rɪˈzɪstəns/	сопротивление, դիմադրություն

Ex. II. Answer the following questions on the text "Electricity and Magnetism"

1. What is called an electric current?
2. What is resistance?
3. What factors affect electrical resistance?
4. Define ohm.
5. What materials have low resistance?
6. Is the resistance of manganin affected by temperature rise?

Ex. III. Give English equivalents for the following words and expressions:

Постоянный ток/հաստատուն հոսանք, единица величины тока/հոսանքի չափման միավոր, направление/ուղղություն, проводник/հաղորդիչ, сталкиваться/բախվել, сечение проводника/լայնույթի հատում, сопротивление/դիմադրություն, температурный коэффициент сопротивления/դիմադրության ջերմային գործակից, электрическое поле/էլեկտրական դաշտ, магнитное поле/մագնիսական դաշտ, амперметр/ամպերմետր, повышать/մեծացնել, понижать/փոքրացնել:

Ex. IV. Give Russian/Armenian equivalents for the following words and expressions:

To associate, to accompany, to project, to term, initial resistance, variable, vacuum, quantum, to possess, to radiate, obvious, distinct, objective, transverse, constant, to repel, to attract, to interact, to distribute, electrical resistance, cross-section, permanent, precise, initial resistance, electric current, continuous flow, to release energy, temperature rise, in direct proportion with.

Ex. V. Arrange the words given in a) and b) in pairs of antonyms:

a	b
valid	to forbid
to permit	to exclude
opaque	wrong
to create	careless
exact	complexity
simplicity	transparent
careful	to destroy
to contradict	hard
to include	to absorb
soft	rough
to emit	final
initial	foreign
familiar	to agree

Ex. VI. Finish the sentences based on the information obtained from the text:

1. The flow of electrons in a conductor is …
2. While in motion along conductor…
3. The motion of electrons along conductor…
4. The unit of electrical conductor is…
5. The temperature coefficient of resistance is…

Ex. VII. Translate the following sentences:

1. If sphere A is continuously charged with positive electricity and sphere B with negative electricity, there will be a continuous flow of electric current in the conductor.
2. As a result of these impacts, energy is released in the form of heat.
3. While in motion along conductor, electrons collide with other electrons, atoms or molecules.
4. The resistance of a conductor can be found from the equation.
5. The change in the resistance of a conductor per ohm of the initial resistance and per degree change of temperature is termed the temperature coefficient of resistance.

READING 2.

The first new science to arise after the end of the Newtonian period was electricity, in part because it was almost the only aspect of physical science to which Newton himself had not devoted his attention and where his great prestige did not frighten off lesser investigators. Electricity had had a long and legendary past. The phenomena of electrostatics and magnetism were known to ancient men as early as 600B.C. The ancient Greek philosophers thought magnetic and electric forces to be of common origin.

Science of magnetism, however, only began when its power could be used to good purpose, as in the compass. In its early stages however, magnetism didn't seem to promise any profitable application. It was a philosophic toy and lay a little outside the interests of the time, which were turned so largely to mechanics and the vacuum.

Some experiments with electricity were made in the early 18^{th} century. One of them was made by the English amateur Stephen Gray that led him in 1729 to a discovery of the transmission of electricity.

Despite all the advances electricity and magnetism remained mysterious and their quantitative study could not begin until some method could be found of measuring them. This was the work of Coulomb in 1785. He established that the forces between magnetic poles as well as those between charges of electricity obeyed the same laws as those of gravity, that is, a force proportional inversely to the distance. These experiments enabled the whole apparatus of Newtonian mechanics to be applied to electricity, but with this difference: that in electricity repulsive as well as attractive forces to be found.

The multiple analogies between electricity and magnetism made physicists think that there must be some connection between them but it was one very difficult to find. It was not until 1820 that through another accident at the lecture table, Oersted in Copenhagen found that the electric current deflected a compass needle. He thus joined together, once and for all, the sciences of electricity and magnetism. One immediate consequence was the invention of the electromagnet, then the electric telegraph and the electric motor.

Ex. VIII. Answer the questions on the text:

1. What could you say about long and legendary past of electricity?
2. When did magnetism and electricity appear as a science?
3. Why did electricity attract little attention during the Newtonian period?
4. What discovery did Coulumb make?
5. Why was his discovery of great importance?
6. What did Oersted accidentally find?
7. Why was this discovery of great importance?
8. What inventions followed all these discoveries?

Ex. IX. Find equivalents:

A	B
Simple	Похожий, նման
To term	Поддерживать, աջակցել
To support	Разноименные заряды, տարանուն լիցքեր
To decrease	Простой, հասարակ
Unlike charges	Уменьшать, պակասեցնել
Lack	За исключением, բացառությամբ
As regards	Увеличивать, ավելացնել
Except	Отталкивать, վանել

To repel	Что касается, ինչ վերաբերում է
To increase	Недостаток, պակասություն
Similar	Для того, чтобы, որպեսզի
In order to	Называть, անվանել

Ex. X. Translate the following sentences into English:

1. Великий английский математик и физик Исаак Ньютон сформулировал общие законы движения тел.
Անգլիացի մեծ մաթեմատիկոս և ֆիզիկոս Իսահակ Նյուտոնը ձևակերպել է մարմինների շարժման ընդհանուր օրենքները:
2.Закон инерции часто называют первым законом Ньютона.
Իներցիայի օրենքը հաճախ կոչվում է Նյուտոնի առաջին օրենք:
3. Второй закон Ньютона говорит о том, как изменяется скорость тела, когда на него действуют силы.
Նյուտոնի երկրորդ օրենքն այն մասին է, թե ինչպես է մարմնի արագությունը փոխվում, երբ նրա վրա ազդում են ուժեր:
4. Закон равенства действия и противодействия был открыт Ньютоном и назван им третьим законом.
Ազդեցության և հակազդեցության մասին օրենքը հայտնաբերեց Նյուտոնը և այն կոչեց շարժման երրորդ օրենք:
5. Сила действия равна силе противодействия.

Ազդեցության ուժը հավասար է հակազդեցության ուժին։

Read the text and think of other applications of electricity in your daily life:

Electricity in Daily Life

In almost any kind of the country it is not uncommon for the power to be “off” for a short time. Lightning, high winds, or sleet storms are in most cases responsible. Usually the service is soon restored.

Transmission of electric currents. The dangers from electric currents in homes are relatively slight. They are rendered so by safe-guards such as insulation, switches, divided circuits, and fuses. All these provide protection both against fires and against accidents to people.

Insulation. Plastics and hard rubber are the insulating materials most commonly used for making the handles of electric appliances. Insulation on electric appliances serves chiefly to prevent injury from electric shock to the people who use the appliances. Insulation on wires serves to prevent short circuits.

Switches. All switches serve the same purposes, namely, to complete circuits or to break them when desirable or necessary.

Series and parallel circuits. A series circuit is one continuous path through which all the current must flow from one terminal of the source of the current to the other.

Using electric currents for heating. Electricity is the cheapest source of energy when used to run motors for doing work. But it is expensive when use for producing heat. Coal, oil, and gas provide heat energy at about half the cost of producing it with electricity. Nevertheless, electricity is increasing in use for ranges and electric heaters, as well as for other heating appliances, because it is clean and convenient.

The heating elements of electric heating devices are usually wires or rods made of metals or metal alloys of high resistance. The high resistance causes these elements to become heated to incandescence when a current passes through them. In most cases the heat and not the light is desired. In ordinary electric lamps, however, the light that accompanies the heat is desired product.

SPEAKING

Make a short presentation on the following topic:
The emergence of electricity; historical background.

Grammar exercises

1. Make necessary changes using the modal verbs (should, must, shouldn't, mustn't):

1. Our scientific adviser insists on taking part in the conference in London.
2. He advised on working hard as it was demanded.
3. The tutor doesn't insist on repeating the experiment.
4. The teacher advised to be careful with acids.
5. He insisted on distinguishing between the center of mass and the center of gravity.

Key: 1. Our scientific adviser says that we must take part in the conference in London.

2. Read the article and choose the correct answer:

Dry ski slopes are a cheap and effective way of learning to ski before you take the plunge and book that expensive holiday in the mountains. But, as with all sports, there are several dos and don'ts that you should know before you start. Skiers have to be reasonably fit. Skiing can be physically demanding. If you are in any doubt about your fitness you (1) .... get a check-up from your doctor before using the slope. You (2) .... be an experienced skier – all levels of ability are welcome on the dry ski slope. You (3) .... wear skis at all times on the slope – it isn't safe to walk on it in ordinary shoes. (You (4) .... bring your own skis, they are available to hire.) You (5) .... wear special clothes when you are on the dry ski slope, but we recommend that you wear strong gloves as the surface of the slope can easily burn your hands if you fall. Because of safety regulations, children under the age of sixteen (6) .... wear protective helmets. Most dry ski slopes have a café or restaurant so you (7) .... to bring your own food or drinks. But remember that food and drinks (8) .... be taken onto the ski slope at any time, because of the risk of accidents.

1. A will need to	B mustn't	C won't need to
2. A needn't	B must not	C don't have to
3. A need	B don't need to	C must
4. A have got to	B don't have to	C have to
5. A needn't	B mustn't	C don't have to
6. A didn't have to	B must	C need
7. A must not	B needn't	C don't need
8. A needn't	B must not	C don't need to

Ex. XI. Translate the following sentences into English paying attention to the modal verbs:

1. Возможно, что в мире существуют некоторые другие частицы помимо нейтронов и протонов.
Հնարավոր է, որ աշխարհում նեյտրոններից և պրոտոններից բացի այլ մասնիկներ կան:
2. То же самое может произойти с атомами в магнитном поле.
Նույնը կարող է կատարվել մագնիսական դաշտի ատոմների հետ:
3. В качестве примера «вектора» можно указать скорость, импульс, силу и ускорение.

«Վեկտորի» օրինակ կարող են լինել արագությունը, իմպուլսը, ուժը և արագացումը:

4. Конденсорная линза может быть применена, когда источник света слабый.

Կոնդենսորային ոսպնյակը կարող է կիրառվել, երբ լույսի աղբյուրը թույլ է:

5. Нужно различать центр массы и центр тяжести.

Պետք է տարբերել զանգվածի կենտրոնը ծանրության կենտրոնից:

6. Следующая проблема, которую мы должны решить: что получится, если тела имеют две разные массы.

Հաջորդ խնդիրը, որը մենք պետք է լուծենք, այն է, թե ինչ է տեղի ունենում, եթե մարմիններն ունեն երկու տարբեր զանգվածներ:

7. Давайте вычислим исходя из второго закона Ньютона, как должна меняться кинетическая энергия.

Հաշվենք, հիմնվելով Նյուտոնի երկրորդ օրենքի վրա, թե ինչպես պետք է փոխվի կինետիկ էներգիան:

8. Вам следует быть осторожнее с кислотами.

Պետք է զգույշ վարվել թթուների հետ:

9. Вам не нужно приходить в 5 часов.

Ժամը 5-ին գալու կարիք չկա:

10. Нам нужно найти другую форму энергии.

Մենք պետք է գտնենք էներգիայի այլ տեսակ:

LISTENING

Scan the QR code, watch the video and answer the questions on the topic:

1. Who was the first to detect electrical phenomena?
2. What did William Gillbert discover?
3. What is the difference between electric and elastic properties of an object?
4. What is a lightning cloud according to Franklin?
5. How do the electrons flow?

Enjoy yourself

Science teacher: Are you sleeping in class?
Student: No teacher. Head is falling down due to gravity.

UNIT VI.

Ex. I. Read the text paying attention to the new vocabulary:

Science is spectral analysis. Art is light synthesis
Karl Krau

REFLECTION AND REFRACTION

All substances have the power to reflect light (to a greater or lesser degree), to turn it back into the medium from which it came. Light that is not reflected is either absorbed (in an opaque substance) or transmitted (in an optical medium). Most ordinary substances reflect light selectively, certain wavelengths (color) being reflected, while the others are absorbed. This phenomenon accounts for the coloring of ordinary objects, whose hue is that of the light which they reflect.

When the surface from which light is reflected is smooth, the reflection is regular; a concentrated beam of light reflected from such a surface will remain a concentrated beam. On the other hand, if the surface is rough, the reflected light will be scattered. This is diffuse or irregular reflection.

Very smooth surfaces of metal are the best reflectors, and this property is made use of in ordinary mirrors. The glass in a mirror is present merely as a support for the silver coat, which is the real mirror. Such surfaces may reflect as much as 98% of perpendicularly incident light. The reflection from such a surface is, of course, regular.

The surface of a transparent medium will also reflect light, and the proportion of the incident light which is reflected will depend upon the angle of incidence. If the light strikes the surface perpendicularly, there will be little reflection; but if it strikes nearly at grazing incidence, the amount of light reflected will be very great.

The law of reflection states that, in any case of reflection, the reflected ray lies in the plane of incidence, and the angle of reflection is equal to the angle of incidence. The angles of incidence and reflection are the angles made by the corresponding rays with normal.

The phenomenon of refraction was known for centuries before the law governing it was discovered. Briefly, the law is:

$$n_a \sin l = n_\beta \sin l'$$

Where n_a and n_β are constants of the media containing the incident and the refracted rays, respectively, and l and l′ are the angles of incidence and refraction, respectively, both measured from the normal to the ray at the point of incidence.

If we define optical density as a measure of the property of slowing down light, so that a medium of large optical density has a small index of refraction, the light travelling more slowly in the former case than in the latter, we can state the general rule: In passing obliquely from one optical medium to another, a ray of light will be deviated toward the normal when passing into a medium of greater optical density, and away from the normal when passing into a medium of lesser optical density.

The index of refraction measures the optical density of a medium. The optical density has no casual relation with the physical density (specific gravity) of a substance, although it is usually true that substances with a high specific gravity have a high index of refraction. This is especially true with various types of the same substance, such as glass, which at one time was catalogued by specific gravity that the index of refraction would be proportional to it; but there are many cases where a substance of relatively low specific gravity has a high index of refraction, as witness the diamond, which has one of the highest known indices of refraction of any optical medium.

The index of refraction of a vacuum is, of course, 1.00000; that of air at standard pressure and temperature is 1.0003. so nearly "l" that it is usually taken as unity. These are absolute indices of refraction. However, in the case of refraction from one medium to another where neither of the media is a vacuum or air, it is easier to deal with relative indices of refraction, which are the ratios of the absolute indices of the media in question. In almost every circumstance, these relative indices (and the absolute indices as well), are found to be between the values ½ and 2.

Study the basic vocabulary

Word	Pronunciation	Translation
Absorb, v	/əbˈzɔːb/	поглощать, всасывать, կլանել

Account, v	/əˈkaʊnt/	учитывать, հաշվի առնել
Beam, n	/biːm/	пучок света, լույսի փունջ
Curve, n	/kɜːv/	изгиб, կոր, թեքու-թյուն
Deviate, v	/ˈdiːvieɪt/	отклоняться, շեղվել
Derive, v	/dɪˈraɪv/	происходить, առաջանալ
Diffuse, adj	/dɪˈfjuːs/	диффузный, դիֆուզ
Distorted, adj	/dɪˈstɔːtɪd/	искаженный, աղավաղված
Incident ray		падающий луч, ընկնող ճառագայթ
Medium, n	/ˈmiːdiəm/	среда, միջավայր
Obliquely, adv	/əˈblːkˌli/	наискосок, косо, թեք
Perpendicular, adj	/ˌpɜːpənˈdɪkjələ(r)/	перпендикулярный, ուղղահայաց
Plane, n	/pleɪn/	плоскость, հարթություն
Ray, n	/reɪ/	луч, ճառագայթ
Ratio, n	/ˈreɪʃiəʊ/	соотношение, հարաբերակցություն
Rough, adj	/rʌf/	неровный, шерохо-ватый, կոպիտ, ոչ հարթ
Smooth, adj	/smuːð/	гладкий, ровный, հարթ

Strike, v	/straɪk/	ударять, стукнуть, հարվածել
Surface, n	/ˈsɜːfɪs/	поверхность, մակերես
Transparent, adj	/trænsˈpærənt/	прозрачный, թափանցիկ
Transmit, v	/trænzˈmɪt/	передавать, транслировать, փոխանցել

Ex. II. Answer the questions on the text:

1. Do all substances reflect light?
2. In what substances is light absorbed?
3. In what medium is light transmitted?
4. What surfaces are the best reflectors?
5. Does the surface of a transparent medium reflect light?
6. Is the reflection great when the light strikes the surface perpendicularly?
7. What is called the angle of incidence?

Ex. III.Give English equivalents for the following words and expressions:

Вещество/նյութ, другим способом/այլ կերպ, благодаря/շնորհիվ, на основе/հիման վրա, и так далее/և այլն, таким образом/այդ կերպ, в результате/արդյունքում, до такой степени/այդ չափով, падаюший свет/ընկնող լույս, среда/միջավայր, согласно с/համաձայն, гладкий/հարթ, грубый/կոպիտ, размытый/աղավաղված, прозрачный/թափանցիկ, поглощать/կլանել, вывести/բխել, пучок света/լույսի փունջ, соотношение/հարաբերակցություն, плоскость/հարթություն, изгиб/թեքություն, поверхность/մակերևույթ, передавать./փոխանցել:

Ex. IV. Give Russian/Armenian equivalents for the following words and expressions:

To emit light, unit area, directly proportional, optical medium, plane, hue, to reflect light selectively, wavelength, source of light, luminous intensity, inversely proportional, cases of luminescence, transparent medium, angle of incidence, to transmit light, rough surface, indices of refraction, optical density, incident ray, grazing incidence, high optical density.

Ex. V. Match the words with their definitions:

Density	Intersecting a given line or surface at right angels
To scatter	The quantity of mass per unit volume of a substance
To deviate	Deflect or diffuse
To diverge	The substance in which an organism lives or is cultivated
Medium	Depart from usual or accepted standards

Normal	Throw in various random directions
To converge	Come from different directions and meet

READING 2.

THEORIES OF LIGHT

There are different kinds of light sources, some of them are caused by high temperatures, others by some other factors. Every source of light is known to have a luminous intensity, which is measurable. In general, the higher is the temperature of the source, the greater the luminous intensity of the light it emits. Incandescence is the emission of light caused by high temperatures. To produce light by incandescence, we maintain the object we are using as a source at a high temperature relative to, say, room temperature. Under these conditions a substance becomes white or bright-red hot and emits light. Certain substances emit light without becoming incandescent; we consider them to be luminescent. Luminescence is the emission of light from a body from any cause other than high temperature. We consider fluorescence and phosphorescence to be particular cases of luminescence. The illumination of a surface is called illuminance and it is the amount of light falling on unit area of the surface per second. The derived unit of illumination in SI system of units is the lux (lumen per square meter). Illuminance is directly proportional to the luminous intensity of the source. However, it depends not only on the luminous intensity of the source but also on the distance of the illuminated area from the source of light. Illuminance is inversely proportional to the square of the distance from the source.

Study the basic vocabulary

Word	Pronunciation	Translation
Bulb, n	/bʌlb/	лампочка, լամպ
Derive, v	/dɪˈraɪv/	происходить, բխել, ածանցել
Emit, v	/iˈmɪt/	издавать, извергать, излучать, արտանետել
Flame, n	/fleɪm/	огонь, пламя, բոց
Fluorescence, n	/fləˈresns/	флуоресценция, свечение, ֆլուորեսցենցիա
Illuminate, v	/ɪˈluːmɪneɪt/	освещать, լուսավորել
Illuminance, n	/ɪˈluːmɪnəns/	освещенность, լուսավորություն
Intensity, n	/ɪnˈtensəti/	интенсивность, сила, ինտենսիվություն
Incandescence, n	/ˌɪnkænˈdesns/	накаливание, накал, շիկացում

Inversely, adv	/ˌɪnˈvɜːsli/	обратно, обратно пропорционально, հակադարձ
Luminous, adj	/ˈluːmɪnəs/	светящийся, լուսավոր
Lux, n	/lʌks/	люкс (единица измерения освещенности) լյուքս/լուսավորության չափման միավոր
Measurable, adj	/ˈmeʒərəbl/	измеримый, осязаемый, չափելի
Phosphorescence,	/ˌfɒsfəˈresns/	фосфоресценция, ֆոսֆորեսցենցիա
Proportional, adj	/prəˈpɔːʃənl/	пропорциональный, համամասնական
Translucent, adj	/trænzˈluːsnt/	полупрозрачный, կիսաթափանց

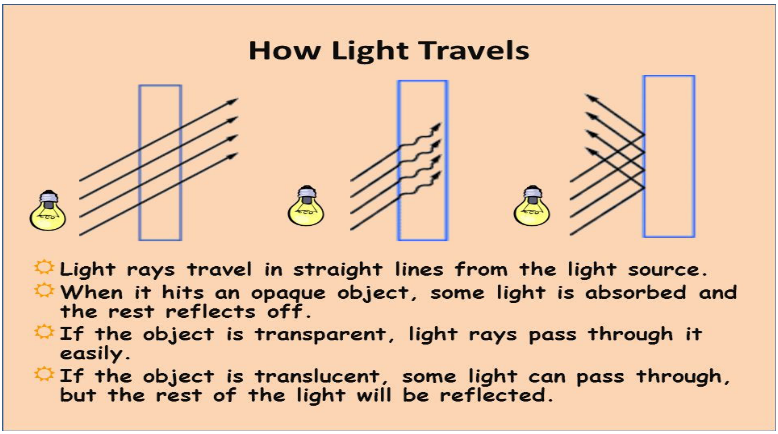
Ex. VI. Read the text and fill in the gaps with the words in brackets, three words are extra:
(bend, incidence, light, normal, optical effect, refracted, refraction, transparent)

When a pencil is half submerged in a beaker of water, the pencil should appear to bend at the point it enters the water. This 1…….. is due to refraction. When light passes from one 2…….. medium to another, such as from air to water, its speed changes. This change in speed causes the light to

3………When light travels from a less dense medium, such as air, to a denser medium, such as glass or water, 4………bends towards the normal but when it travels from a denser medium to a less dense medium it bends away from the 5……..

Ex. VII. Read the short passage and interpret it:

Light travels in a straight line, which is why we cannot see around corners. In diagrams light is generally represented a straight lines with arrowheads pointing in the direction in which the light travels. A single ray of light cannot be seen but when they come together they become visible. These lines are called rays and a collection of equally spaced rays is called a beam light. There are different types of beams. Rays which do not meet are known as a parallel beam light. Those rays which start from a source and spread out from this point are called a diverging beam and rays which come together to a point are known as converging beam.



Ex.VIII. Choose the best option:

1. The lux is a unit used to measure (luminous intensity/illuminance) in SI units.
2. We use the standard candle to measure the luminous intensity of (only some/any) luminous objects.
3. All luminous objects emit (the same amount/ different amounts) of light.
4. I lluminance of a surface is (directly/inversely) proportional to the luminous intensity of the source and (directly/inversely) proportional to the square of the distance from the source.
5. A source of light which is (large/small) compared to the area it illuminates is called a point source.

Ex. IX. Translate into Russian/Armenian paying attention to the participles:

1. Moving around the nucleus, and at a considerable distance from it, are the rest of the electrons required to make the atom neutral.
2. The results of the above mentioned calculations are reported in two tables.
3. Closely related to the true catalyzed reactions are ‘induced reactions’.
4. A conduction current is a current flowing in a conductor.
5. The three levels not included in this calculations are given in brackets.
6. An inertialess charge placed in an electric field would follow a path called a line of force.

7. Fig. 2 shows a positively charged sphere A and a conductor B placed in the field of a sphere.
8. The above mentioned experimental results are in good agreement with theoretical data.

Ex. X. Translate into English paying attention to the participles:

1. Солнце – основной естественный источник света и тепла.

Արևը լույսի և ջերմության միակ հիմնական աղբյուրն է:

2. Скорость света была впервые измерена во второй половине VII века.

Լույսի արագությունն առաջին անգամ չափվել է VII-րդ դարի երկրորդ կեսին:

3. Угол отражения равен углу падения.

Անդրադարձման անկյունը հավասար է անկման անկյանը:

4. При переходе из одной среды в другую луч света изменяет направление на границе этих сред. Это явление называется преломлением света.

Մի միջավայրից մյուս միջավայր անցնելիս լույսի ճառագայթը փոխում է իր ուղղությունը երկու միջավայրերի սահմանին: Այդ երևույթը կոչվում է բեկում:

5. При переходе луча света из оптически более плотной среды в среду менее плотную угол преломления больше угла падения.

Օպտիկական ավելի խիտ միջավայրից ավելի նոսր միջավայր անցնելիս բեկման անկյունն ավելի մեծ է անկման անկյունից։

SPEAKING

Read the text and render the main information:

Characteristics of Lenses

A lens is a piece of transparent material, usually circular in shape, with two polished surfaces, either or both of which is curved and may be either convex or concave. The curves are almost always spherical; i.e., the radius of curvature is constant. A lens has the valuable property of forming images of objects situated in front of it. Single lenses are used in eyeglasses, contact lenses, pocket magnifiers, signal lights, viewfinders, and on simple box cameras. Compound lenses are used in such instruments as cameras, microscopes, and telescopes.

Optical principles for lenses

A lens produces its focusing effect because light travels more slowly in the lens than in the surrounding air, so that refraction, of a light beam occurs both where the beam enters the lens and where it emerges from the lens into the air.

A single lens has two precisely regular opposite surfaces; either both surfaces are curved or one is curved and one is plane. Lenses may be classified according to their two surfaces as biconvex, plano-convex, concavo-convex, biconcave, plano-concave, and convexo-concave. Because of the curvature of the lens surfaces, different rays of an incident light beam are refracted through different angles, so that an entire beam of parallel rays can be caused to converge on, or to appear to diverge from, a single point. This point is called the focal point, or principal focus, of the lens. Refraction of the rays of light reflected from or emitted by an object causes the rays to form a visual image of the object. This image may be either real-photographable or visible on a screen-or virtual-visible only upon looking into the lens, as in a microscope. The image may be much larger or smaller than the object, depending on the focal length of the lens and on the distance between the lens and the object. The focal length of a lens is the distance from the centre of the lens to the point at which the image of a distant object is formed. A long-focus lens forms a larger image of a distant object, while a short-focus lens forms a small image.

LISTENING

Scan the QR code, watch the video and answer the questions on the topic:

1. How did light originate according to Plato and Pythagoras?

2. How does it get dark sometimes?
3. What did Newton believe in?
4. What properties does light possess?
5. What is the theory of quantum mechanics about?

Enjoy yourself

A disgusted guest at a restaurant: You can't expect me to eat this stuff! Call the manager!
Waiter: It's no use, sir, he won't eat it either.

UNIT VII.

Ex. I. Read the text paying attention to the new vocabulary:

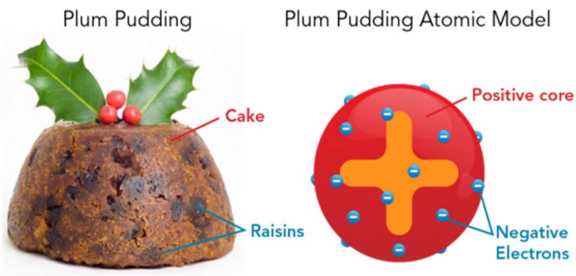
The splitting of the atom has changed everything
except for how we think
Albert Einstein

ATOMS, ELEMENTS AND COMPOUNDS

It's difficult to say definitely who was the first to say the word "atom"; perhaps, that was the ancient Greek philosopher Democritus (5–4 B.C.). The word "atom" comes from Greek and means "that which has no parts". The atom we know is far from being solid and indivisible, but we continue to use the word to designate the smallest particle which takes part in chemical interactions. The origin of atomic physics as a branch of science can be attributed to Rontgen's discovery of X-rays. It was this discovery that enabled J.J. Thomson to complete his understanding of the generators of X-rays-the cathode rays or electrons.

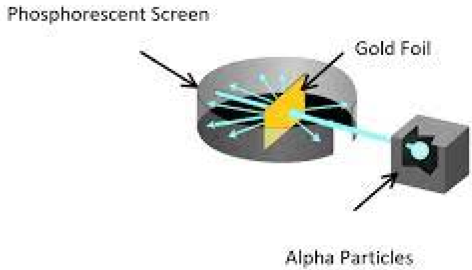
In the early 1900's, the plum pudding model was the accepted model of the atom (Fig.1). Proposed in 1904 by J. J. Thomson, the model suggested that the atom was a spherical ball of positive charge, with negatively charged electrons scattered evenly throughout. In that model, the positive charges made up the pudding, while the electrons acted as isolated plums. During its short life, the model could be used to explain why most particles were neutral, although with an unbalanced number of plums, electrically charged atoms could exist.

Fig. 1. J.J. Thomson's model of an atom



When Ernest Rutherford began his gold foil experiment in 1909, it is unlikely that anyone would have expected that the plum pudding model would be challenged. However, using a radioactive source, a thin sheet of gold foil, and a phosphorescent screen, Rutherford would uncover something so great that he would later call it "the most incredible event that has ever happened to me in my life" [James, L.K. (1993). Nobel Laureates in Chemistry, 1901–1992. Washington, DC: American Chemical Society.] The experiment that Rutherford designed is shown in Figure 2. As you can see in, a radioactive source was placed in a lead container with a hole in one side to produce a beam of positively charged helium particles, called alpha particles. Then, a thin gold foil sheet was placed in the beam. When the high-energy alpha particles passed through the gold foil, they were scattered. The scattering was observed from the bright spots they produced when they struck the phosphor screen.

Fig.2. Rutherfod's gold foil experiment.



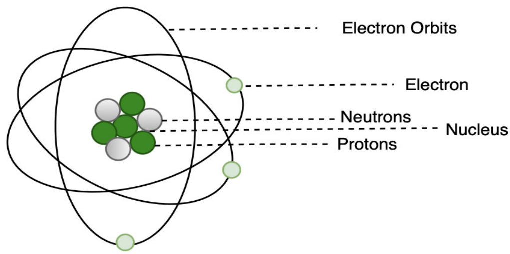
The expectation of the plum pudding model was that the high-energy alpha particles would be scattered only slightly by the presence of the gold sheet. Because the energy of the alpha particles was much higher than those typically associated with atoms, the alpha particles should have passed through the thin foil much like a supersonic bowling ball would crash through a few dozen rows of bowling pins.

Any deflection was expected to be minor, and due primarily to the electrostatic Coulomb force between the alpha particles and the foil's interior electric charges.

In 1910 two of Rutherford's workers, Geiger and Marsden showed that the alpha particles, instead of going straight through thin sheets of matter were occasionally shot straight back. He drew the

conclusion that the alpha particle must have hit something very small and very hard. He understood that atoms had nuclei. Based on the size and mass of the nucleus revealed by his experiment, as well as the mass of electrons, Rutherford proposed the planetary model of the atom (Fig.3)

Fig. 3. Rutherford's Model of Atoms.



Study the basic vocabulary

Word	Pronunciation	Translation
Arrangement, n	/əˈreɪndʒmənt/	договоренность, приготовления կարգավորում, համաձայնեցում
Attribute, v	/əˈtrɪbjuːt/	приписывать, относить վերագրել
Cathode, n	/ˈkæθəʊd/	катод, կաթոդ

Decisive, adj	/dɪˈsaɪsɪv/	решающий, որոշիչ
Deflection, n	/dɪˈflek.ʃən/	отклонение, շեղում
Designate, v	/ˈdezɪgneɪt/	обозначать, определять, նշանակել, բնութագրել
Enable, v	/ɪˈneɪbl/	разрешать, включать թույլատրել, միացնել
Extract, v	/ˈekstrækt/	извлекать, удалять հեռացնել, հանել
Evenly, adv	/ˈiː.vən.li/	равномерно, հավասարաչափ
Generate, v	/ˈdʒenəreɪt/	производить, образовывать, արտադրել
Indivisible, adj	/ˌɪndɪˈvɪzəbl/	неделимый, անբաժանելի
Nucleus, n	/ˈnjuːkliəs/	ядро, ячейка, միջուկ
Radius, n	/ˈreɪdiəs/	радиус, շառավիղ
Reject, v	/rɪˈdʒekt/	отклонять, մերժել
Revolve, v	/rɪˈvɒlv/	вращаться, պտտվել
Scatter, v	/ˈskætə(r)/	разбрасывать, ցրել, տարածել
Shoot, v	/ʃuːt/	отстреливать, взрывать, կրակել
Solid, adj	/ˈsɒlɪd/	твердый, сплошной, պինդ
Substance, n	/ˈsʌbstəns/	вещество, материя, նյութ

Suppose, v	/səˈpəʊz/	предполагать, допускать, ենթադրել
Uniformly, adv	/ˈjuːnɪfɔːmli/	равномерно, միատեսակ

Ex. II. Answer the questions on the text:

1. What is the origin of the word "atom"?
2. When and how did the atomic physics as a branch of science originate?
3. What model of the atom did Thomson suggest?
4. Why was his hypothesis short-lived?
5. What did Rutherford and his workers observe in their experiments?
6. What model of atom did Rutherford suggest?
7. What do you know about atom now?
8. What is the structure of the oxygen atom?

Ex. III. Give English equivalents for the following words and expressions:

Отклонение/շեղում, можно отнести к/կարելի է վերագրել, сделать первый решительный шаг/կատարել առաջին, որոշիչ քայլ, внутренняя структура/ներքին կառուցվածք, сходное решение/նման որոշում, распределены в атоме/տեղակայված ատոմի մեջ, по предположению/ենթադրաբար, рассеяны вокруг/ցրված շուրջը, иногда отскакивали назад/

երբեմն ետ ցատկել, что-то очень твердое/ինչ-որ պինդ մարմին, расположение планет/մոլորակների դասավորվածություն:

Ex. IV. Give Russian/Armenian equivalents for the following words and expressions:

High energy electron scattering, alpha-particle scattering, attribute to, electric charges, beta beam path, field-strength pattern, ion beam deflection, liquid-hydrogen target, X-ray lead screen, gold foil, phosphorescent screen, α-particle scattering experiment, opposite charge, indivisible, like charge, fixed charge, unit charge, induced charge, radioactive source.

Ex. V. Finish the sentences according to the information from the text:

1. As a branch of science atomic physics is concerned with…
2. According to Thomson's model the atom…
3. The word "atom" comes from…and means…
4. In their experiments Rutherford and his colleagues observed…
5. Rutherford came to the conclusion that atom…
6. Rutherford's model of the atom is called…because… .

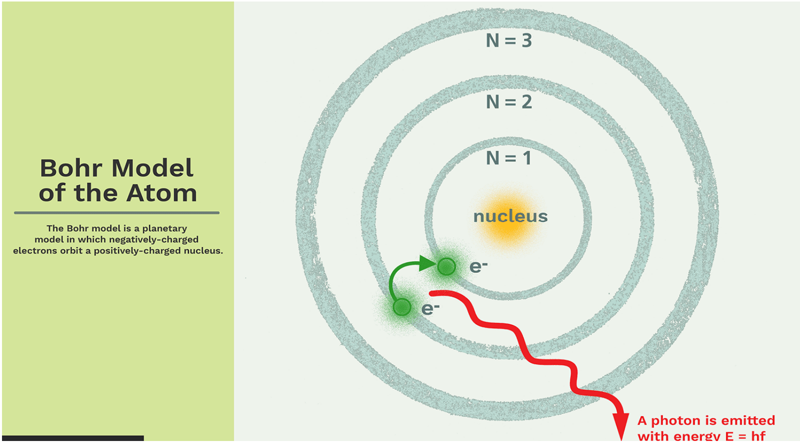
Ex.VI. Read the following text and render it:

The Bohr Atom

Bohr, born in October 1885, was about ten years old when the electron was discovered, and he began his professional career in 1911, the year in which Rutherford discovered the **atomic nucleus.** Thus, he came onto the scene at the very beginning of the new era in the physics of atom. Thereafter, for 50 years he was actively involved into latest discoveries and ideas and when he died in November 1962, the word of physics knew that it had lost one of its greatest figures.

Bohr proposed not only a structure for the atom that satisfactorily explained the Balmar Formular for **hydrogen spectrum lines**, but a principle upon which to build the electron structure of all atoms and molecules. As we have seen, the hydrogen atom consists of a **positively charged nucleus** and a single negatively charged electron. The **electron orbits** the nucleus is much the same as a planet like the Earth moves around the Sun. Because the nucleus has 1840 times the mass of the electron, it may be thought that it is more or less stationary. To move on a circular path the electron has to have a **centripetal force** – a force pulling it toward the center. This force is expressed by equation:

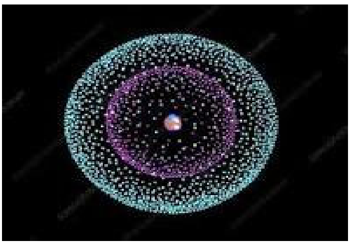
$$F = m\frac{\upsilon 2}{r}$$



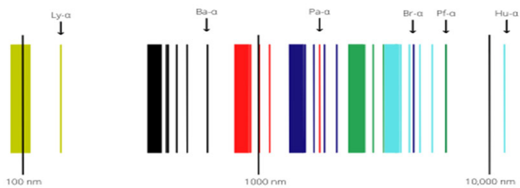
Planetary Model of the Hydrogen Atom

Notes to the text.

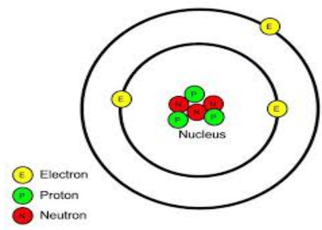
Atomic nucleus – Atomic nuclei consist of **electrically positive protons and electrically neutral neutrons**. These are held together by the strongest known fundamental force, called the strong force.



Hydrogen spectrum lines – The emission spectrum of atomic hydrogen has been divided into a number of spectral series, with wavelengths given by the Rydberg formula. These observed spectral lines are **due to the electron making transitions between two energy levels in an atom**.

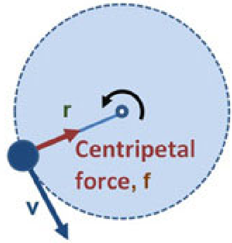


Positively charged nucleus – An atom consists of a positively charged nucleus, **surrounded by one or more negatively charged particles called electrons**. The positive charges equal the negative charges, so the atom has no overall charge; it is electrically neutral.



Electron orbits – **Electrical attraction to the nucleus is what keeps the electron in orbit**, and this attraction doesn't cost energy.

Centripetal force – a force that makes a body follow a curved path. Its direction is always orthogonal to the motion of the body and towards the fixed point of the instantaneous center of curvature of the path.



Ex. VII. Translate the following sentences into English:

1. Модель атома Резерфорда напоминает солнечную систему.
Ռեզերֆորդի ատոմի մոդելը հիշեցնում է արեգակնային համակարգը:
2. В центре находится атомное ядро, а вокруг него по своим орбитам движутся электроны.
Կենտրոնում գտնվում է ատոմի միջուկը, իսկ նրա շուրջը պտտվում են էլեկտրոններն իրենց ուղեծրերով:
3. Планетарная модель атома Резерфорда также имела свои неразрешимые противоречия.
Ռեզերֆորդի ատոմի մոդելը նույնպես ուներ իր հակասությունները:

4. Электроны обязательно должны двигаться вокруг ядра, в ровном случае (otherwise) они потеряли бы устойчивость.
Էլեկտրոններն անշուշտ պետք է պտտվեն միջուկի շուրջ, հակառակ դեպքում նրանք կկորցնեն իրենց կայունությունը:
5. Планетарная модель Резерфорда оказалась несовместимой (incompatible with) с электродинамикой Максвелла.
Ռեզերֆորդի ատոմի մոլորակային մոդելն անհամատեղելի էր Մաքսվելի էլեկտրոդինամիկայի տեսության հետ:

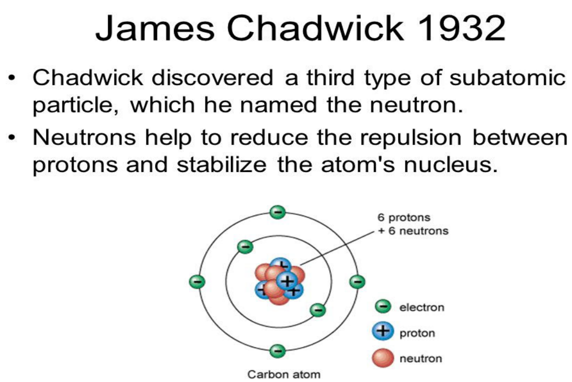
Read the text "Nuclear Physics and make a presentation on the historical development of atoms, electrons and compounds":

Nuclear Physics

In the 1930s radioactivity and the study of the atomic nucleus, which had shown little advance in the previous ten years, again became the center of interest, and gave rise to an unbroken series of experimental discoveries that were to culminate in the control of nuclear processes.

Once recognized and established by Chadwick's experiments of 1932, as the proton without its positive charge, the neutron was seen to be the central feature of nuclear structure. Very soon afterwards Anderson discovered another fundamental particle, the positive electron or positron. The nucleus which had previously been thought to consist of protons and electrons was now seen to be better expressed in terms of protons and neutrons held together by strong forces which Yukawa in 1935 attributed to a hypothetical particle, the meson. This is an example of a fundamental particle first predicted by theory and then observed by Anderson and Neddermeyer in 1936.

Of these particles, the neutron proved to be the most effective in producing nuclear transformations. Because it lacked charge, it was able to penetrate very much farther into the matter and to approach and enter the positively charged nuclei of atoms that repelled positively charged alpha-particles and protons. In six brief years, from 1932 to 1938, the effects of neutrons on different nuclei were studied.



Grammar exercises

1. Complete the sentences and text using Future tenses (Future Simple, to be going to, Future Perfect, and Future Continuous)

1. We …… the room by the time you get back. (finish)
2. The phone is ringing. – I …… and answer it. (go)
3. I …… tomorrow so we can go to the beach. (not work)
4. If you touch the stove, you …… yourself. (burn)
5. She …… for the job that was advertised in the newspaper. (apply)
6. Next week at this time we …… in the sun in Spain. (lie)
7. My sister …… in the UK next year. (study)
8. The President …… Armenia in November. (visit)
9. I …… lunch with Mary at 12. (have)
10. I don't think the exam …… very difficult. (be)

2. At the end of this month, I ……… (work) on my physics project for about six weeks, but I've still got a lot to do before I hand it in. I ………… (spend) the whole day in the physics lab next Saturday doing experiments, and in fact, I ……….. (play) football the weekend after it. I guess I'll ……….. (do) lots of similar projects when I'm at university, so it's good practice. Thinking about it, when I leave university in about four years, I will …….. (study) physics for over thirteen years, so I should be quite good at it by then!

LISTENING

Scan the QR code, watch the video and answer the questions on the topic:

1. What theory did Democritus first proposed in 440BC?
2. What does <u>*atomos*</u> mean in Greek?
3. Aritotel's theory proposed that…
4. What great discovery occurred in 1897?
5. Who was the father of nuclear age?

Enjoy yourself

Visitor: Do you think the horse shoe hanging in your office bring you good luck?
Niels Bohr: Of course, not.
Visitor: Then why do you have it there?
Niels Bohr: Because it works whether you believe in it or not.

UNIT VIII.

Ex. I. Read the text paying attention to the new vocabulary:

If quantum mechanics hasn't profoundly shocked you,
you haven't understood it yet
Neils Bohr

QUANTUM NATURE OF LIGHT

Atoms, molecules, and fundamental electron and proton charges are all examples of physical entities that are quantized – that is, they appear only in certain discrete values and do not have every conceivable value. On the macroscopic scale, this is not a revolutionary concept. When Max Planck was able to use quantization to correctly describe the experimentally known shape of the blackbody spectrum, it was the first indication that energy was quantized on a small scale as well. This discovery earned Planck the Nobel Prize in Physics in 1918 and was such a revolutionary departure from classical physics that Planck himself was reluctant to accept his own idea. The general acceptance of Planck's energy quantization was greatly enhanced by Einstein's explanation of the photoelectric effect, which took energy quantization a step further. When light strikes certain materials, it can eject electrons from them. This is called the photoelectric effect, meaning that light (photo) produces electricity. One common use of the photoelectric effect is in light meters, such as those that adjust the automatic iris in various types of cameras. Another use is in solar cells, as you probably have in your calculator or have seen on a rooftop or a roadside sign. These make use of the photoelectric effect to convert light into electricity for running different devices.

Through careful observations of the photoelectric effect, Albert Einstein realized that there were several characteristics that could be explained only if EM radiation is itself quantized. It means that the apparently continuous stream of energy in an EM wave is actually not a continuous stream at all. In fact, the EM wave itself is actually composed of tiny quantum packets of energy called photons. In equation form, Einstein found the energy of a photon or photoelectron to be $E=hf$ where E is the energy of a photon of frequency f and h is Planck's constant. A beam from a flashlight, which to this point had been considered a wave, instead could now be viewed as a series of photons, each providing a specific amount of energy.

While Einstein's understanding of the photoelectric effect was a transformative discovery in the early 1900s, its presence is ubiquitous today. If you have watched streetlights turn on automatically in response to the setting sun, stopped elevator doors from closing simply by putting your hands between them, or turned on a water faucet by sliding your hands near it, you are familiar with the ***electric eye*****,** a name given to a group of devices that use the photoelectric effect for detection. All these devices rely on photoconductive cells. These cells are activated when light is absorbed by a semi-conductive material, knocking off a free electron. When this happens, an electron void is left behind, which attracts a nearby electron. The movement of this electron, and the resultant chain of electron movements, produces a current. If electron ejection continues, further holes are created, thereby increasing the electrical conductivity of the cell. This current can turn switches on and off and activate various familiar mechanisms.

Study the basic vocabulary

Word	Transcription	Translation
Acceptance, n	/əkˈsep.təns/	признание, одобрение, համաձայնություն, հավանություն
Adjust, v	/əˈdʒʌst/	регулировать, устанавливать, հարմարեցնել, կարգի բերել
Apparently, adv	/əˈpærəntli/	очевидно, явно, ակնհայտորեն
Conceivable, adj	/kənˈsiː.və.bl̩/	возможный, мыслимый, ըմբռնելի
Discrete, adj	/dɪˈskriːt/	отдельный, дискретный, վերացական, անջատ
Eject, v	/ɪˈdʒekt/	выбрасывать, извергать, մերժել, դուրս հանել

Equation, n	/ɪˈkweɪ.ʒən/	уравнение, հավասարում
Faucet, n	/ˈfɔːsɪt/	вентиль, кран, ծորակ
Indication, n	/ˌɪndɪˈkeɪʃn/	указание, показание, ցուցում, նշում
Iris, n	/ˈaɪ.rɪs/	радужная оболочка глаза, ծիածանա-թաղանթ
Quantization, n	/kwɒntɪˈzeɪʃn/	квантование, քվանտայնացում
Reluctant, adj	/rɪˈlʌk.tənt/	вынужденный, դժկամությամբ
Run, v	/rʌn/	работать, вести, дви-гаться, աշխատեցնել, շարժվել
Stream, n	/striːm/	поток, направление, հոսք
Strike, v	/straɪk/	ударять, հարվածել
Thereby, adv	/ˌðeəˈbaɪ/	таким образом, այսպիսով
Ubiquitous, adj	/juːˈbɪk.wɪ.təs/	вездесуший, համատարած, ամենուր
Value, n	/ˈvæljuː/	величина, значение, արժեք
Void, n	/vɔɪd/	пустота, вакуум, դատարկ, անվավեր

Ex. II. Answer the questions on the text:

1. Why did Planck receive the Nobel Prize?
2. What happens to light when it strikes certain materials?
3. Name the uses of photoelectric effect?
4. What is an electric eye?
5. How does current turn switches on and off?

Ex. III. Give Russian/Armenian equivalents for the following words and expressions:

Discrete value, stream, tiny particles, ubiquitous, elevator, macroscopic scale, revolutionary departure, to be reluctant, to take a step further, common use, solar cells, roadside sign, careful observations, in response to, series of photons, semi conductive, chain, current, electron ejection, familiar, turn on/off, thereby, various, to absorb, to slide.

Ex. IV. Give English equivalents for the following words and expressions:

Движение электронов/էլեկտրոնների շարժ, величина/արժեք, революционное явление/ հեղափոխական երևույթ, указание/ցուցում, классическая физика/դասական ֆիզի-կա, на шаг перед/մեկ քայլ առաջ, усиливать/ուժեղացնել, выбрасывать электроны/անջատել էլեկտրոններ, обшее приминение/ընդհանուր կիրառում, солнечные батареи/արևային մարտկոց, преобразовывать свет/փոխակերպել լույսը, тщательно наблюдать/ուշադիր զննում, непрерывный поток энергии/էներգիայի շարունակական հոսք, в виде уравнения/հավասարման տեսքով, закат/արևամուտ, поглощать свет/կլանել լույս, активировать разные механизмы/ակտիվացնել զանազան մեխանիզմներ:

Ex. V. Match each verb with the phrase closest in meaning:

1. to eject	a) to bring to a more corresponding state
2. to run	b) to attack with a sharp blow
3. to adjust	c) to push or force smth. out of a place
4. to strike	d) to change from one form to another
5. to activate	e) to operate, manage
6. to provide	f) to answer to something
7. to convert	g) to put in motion
8. to response	h) to supply smth. to someone
9. to absorb	i) to form an idea, a plan in your mind
10. to conceive	j) to take in

Ex. VI. Find 5 pairs of antonyms in the following set of words:

To eject, response, filled, conversion, to keep, to defend, ubiquitous, to disable, reluctant, to activate, to absorb, to release, void, to attack, to provide, to reject, to adjust, stream.

Ex. VII. Match the sentence halves:

1. The quantum nature of light reveals itself	A. played a significant role in the development of mechanics.
2. Photons, the fundamental particles of light	B. through phenomena like wave-particle duality.
3. Quantum theory shows how light interacts with matter	C. can exist in superposition states.
4. Quantum optics experiments	D. illustrate how single photons can split into pairs of entangled photons.
5. Einstein's explanation of the photoelectric effect	E. leading to photon absorption, emission, and entanglement.

Ex. VII. Translate the following sentences into English:

1. Клетки активируются, когда свет поглощается полупроводниковым материалом, выбивая свободный электрон.
Բջիջներն ակտիվանում են, երբ լույսը ներծծվում է կիսահաղորդչային նյութի կողմից՝ դուրս մղելով ազատ էլեկտրոնը:
2. Это называется фотоэлектрическим эффектом, означающим, что свет производит электричество.
Սա կոչվում է ֆոտոէլեկտրական էֆեկտ, այսինքն՝ լույսը արտադրում է էլեկտրաէներգիա:

3. Движение этого электрона и возникающая в результате цепочка движений электронов создают ток.

Այս էլեկտրոնի և դրա արդյունքում առաջացած էլեկտրոնների շարժումների շղթան ստեղծում է հոսանք:

4. Все эти устройства основаны на фотопроводящих элементах.

Այս բոլոր սարքերը հիմնված են ֆոտոհաղորդիչ մասնիկների վրա:

5. Понимание Эйнштейном фотоэлектрического эффекта стало революционным открытием в начале 1900-х годов.

Ֆոտոէֆեկտի մասին Էյնշտեյնի ընկալումը հեղափոխական հայտնագործություն էր 1900-ականների սկզբին:

Grammar exercises

Use present perfect or past simple.

1. I (buy) a new car two years ago, but I (not sell) my old car yet.
2. When I (be) on my way to the office it (begin) to snow. I (run) back home for a warmer coat, but that (make) me late for my bus.
3. John (be) in Tokyo for three months. He is studying there and likes it very much.

4. I (not see) Bill for some time. He (be) ill, he (collapse) at work a week ago but he (not come) back to work yet.
5. How long you (work) for that company? – I (be) there for a year already.

Fill in the text with the correct tenses (mixed tenses).

Dear sister

I (be) very sorry to hear about your father's illness, and (be) glad that you (go) to Armenia to see how he is. It (be) nice for him to see you. Of course I (look) after Archie. We (enjoy) having him last year and my son (miss) him when he (leave). I'm sure he (be) delighted to see him again. You (bring) him on Wednesday? Or, if that (not suit), any time on Thursday. (not bother) to bring any food; I (have) everything Archie (love). I hope you (have) time to have coffee with us when you (bring) Archi, and that by then you (have) better news of your father.

Read the text and render the main information:

Solar Energy Physics

According to the U.S. Department of Energy, Earth receives enough sunlight each hour to power the entire globe for a year. While converting all of this energy is impossible, the job of the solar energy physicist is to explore and improve upon solar energy conversion technologies so that we may harness more of this abundant resource. The field of solar energy is not a new one. For over half a century, satellites and spacecraft have utilized photovoltaic cells to create current and power their operations. As time has gone on, scientists have worked to adapt this process so that it may be used in homes, businesses, and full-scale power stations using solar cells.

Traversing the Solar System using nothing but the Sun's power has long been a fantasy of scientists and science fiction writers alike. Though physicists like Compton, Einstein, and Planck all provided evidence of light's propulsive capacity, it is only recently that the technology has become available to truly put these visions into motion. In 2016, by sending a lightweight satellite into space, the LightSail-1 project is designed to do just that. A citizen-funded project headed by the Planetary Society, the 5.45-million-dollar LightSail-1 project is set to launch two crafts into orbit around the Earth. Each craft is equipped with a 32-square-meter solar sail prepared to unfurl once a rocket has launched it to an appropriate altitude. The sails are made of large mirrors, each a quarter of the thickness of a trash bag, which will receive an impulse from the Sun's reflecting photons. Each time the Sun's photon strikes the craft's reflective surface and bounces off, it will provide a momentum to the sail much greater than if the photon were simply absorbed. Attached to three tiny satellites called CubeSats, whose combined volume is no larger than a loaf of bread, the received momentum from the Sun's photons should be enough to record a substantial increase in orbital speed. The intent of the LightSail-1 mission is to prove that the technology behind photon momentum travel is sound and can be done cheaply. A test flight in May 2015 showed that the craft's Mylar sails could unfurl on command. With another successful result in 2016, the Planetary Society will be planning future versions of the craft with the hopes of eventually achieving interplanetary satellite travel. Though a few centuries premature, Kepler's fantastic vision may not be that far away.

SPEAKING

1. Prepare a speech on the following topic:

Is installing solar panels or wind turbines still in future or is it already a fact?

2. How will we be living in 30 years' time?

The environment: Fresh water will be running out in many parts of the world and we will be getting much of our water from sea.

At home: People will be recycling 100% of their waste.

The weather: We will be having more extreme weather, heatwaves and floods, etc.

LISTENING

Scan the QR code, watch the video and answer the questions on the topic:

1. Is light a particle or a wave?
2. Who was the first person to suggest the dual nature of light?

3. Where is the mass of the atom concentrated?
4. What did Bohr propose?
5. How can quantum mechanics be explained?

Enjoy yourself

The well-known English atomic scientist Rutherford, the discoverer of the atomic nucleus, came to his laboratory late in the evening. One of the pupils was still busy with the instruments.

"What are you doing here so late?" Rutherford asked the young scientist.

"I am working," came the proud answer.

"And what do you do by day?"

"Work, of course."

"And do you work early in the morning?"

"Yes, professor, I work early in the morning as well," the pupil answered proudly.

Rutherford looked at him with some pity and asked: "And when do you think?"

UNIT IX.

Ex. I. Read the text paying attention to the new vocabulary:

In thinking about nanotechnology today,
what's most important is understanding where it leads,
what nanotechnology will look like
after we reach the assembler breakthrough.
K. Eric Drexler

WHAT QUALIFIES AS SMALL?

Nanotechnology involves the scientific and engineering study of matter at the atomic and molecular level. It is the manipulation and use of materials and devices so tiny that nothing can be built any smaller. Nanomaterials are typically between 0.1 and 100 nanometers (nm) in size - with 1nm being equivalent to one billionth of a meter. If one nanometer was roughly the width of a pinhead, then one meter on this scale would stretch the entire distance from Washington, DC to Atlanta – around 1000 kilometers. But a pinhead is actually one million nanometers wide. Most atoms are 0.1 to 0.2 nm wide, strands of DNA around 2nm wide, red blood cells are around 7000 nm in diameter, while human hairs are typically 80,000 nm across. Throughout history, people have harnessed the unique characteristics of materials on a nanoscale for various purposes. Tiny particles of gold for example, can appear red or green, a property that has been used to colour stained glass windows for over 1000 years. However, the idea of nanotechnology was born only in 1959 when Nobel Prize winning physicist Richard Feynman gave a lecture exploring the idea of building things at the atomic and molecular scale. He imagined the entire Encyclopedia Britannica written on the head of a pin. When K. Eric Drexler popularized the word 'nanotechnology' in the 1980's, he was talking about building machines on the scale of molecules, a few nanometers wide; motors, robot arms, and even whole computers, far smaller than a cell. Drexler spent many years describing and analyzing these incredible devices, and responding to accusations of science fiction. In fact, experimental nanotechnology appeared in 1981, when IBM scientists in Zurich, Switzerland, built the first scanning tunneling microscope (STM). It made it possible to see single atoms by scanning a tiny probe over the surface of a silicon crystal. The nanometer length scale is unique because it makes it possible to change the fundamental properties of materials without altering their chemical composition. Nanoparticles have very high surface areas and their behaviour and mobility can be changed. Nanotechnology allows scientists to specifically analyze, organize and control matter on many length scales simultaneously. This creates unlimited possibilities for products and applications. Advanced nanotechnology, or that which works with artificial intelligence, nanorobots and self - assembly is expected to increase significantly. Nanoparticles are currently used in the electronic, magnetic, optoelectronic, biomedical, pharmaceutical, cosmetic, energy, catalytic and materials industries. In the medical field they are used to aid in drug delivery and medical imaging, and in future nanotechnology is predicted to contribute to new cancer therapies, new treatments for infections and brain diseases and new drugs with fewer side effects. Nanoparticles may be used in contaminant neutralization, magnetic techniques, special filtering methods, environmental decontamination and energy conservation and in the production of energy efficient devices. Nanotechnology involves manipulations of matter at incredibly small levels and its applications appear to be nearly limitless. Cancer cures, shirts that change colour, self-heating/cooling clothes, super processors, the size of sugar cubes, alloys both lighter and stronger than steel are just a handful of the potential applications of this technology that may bring about more change in 25 years than the entire 20th century.

Study the basic vocabulary

Word	Transcription	Translation
Accusation, n	/ˌæk.jʊˈzeɪ.ʃən/	обвинение, մեղադրանք
Aid, n	/eɪd/	помощь, помогать, օգնել, օգնություն
Alter, v	/ˌɒl.təˈreɪ.ʃən/	изменять, переделывать, փոփոխել
Alloy, n	/ˈæl.ɔɪ/	сплав, համաձուլվածք, խառնուրդ
Allow, v	/əˈlaʊ/	позволять, թույլ տալ
Assembler, n	/əˈsemblər/	транслятор, сборка, ասեմբլեր, հավաքող

Behaviour, n	/bɪˈheɪvjə(r)/	поведение, պահվածք
Cancer cure		лекарство от рака, քաղցկեղի բուժում
Cell, n	/sel/	клетка, բջիջ
Contaminant, n	/kənˈtæm.ɪ.nənt/	загрязнитель, աղտոտիչ
Contribute, v	/kənˈtrɪbjuːt/	способствовать, նպաստել, աջակցել
Decontami-nation, n	/ˌdiː.kənˈtæm.ɪ.neɪt/	обеззараживание, дезактивация, ախտահանում, վարակազերծում
Drug, n	/drʌg/	лекарство, դեղամիջոց
Efficient, adj	/ɪˈfɪʃnt/	продуктивный, эффективный, արդյունավետ
Entire, adv	/ɪnˈtaɪə(r)/	весь, целый, ամբող-ջական, լիակատար
Environmental, adj	/ɪnˌvaɪrənˈmentl/	относяшийся к окружаюшей среде բնապահպանական
Incredible,	/ɪnˈkred.ɪ.bl̩/	невероятный, անհավանական
Mobility, n	/məʊˈbɪl.ɪ.ti/	подвижность, շարժունակություն
Optoelectronic, adj		оптоэлектронный, օպտոէլեկտրոնային

Pinhead, n	/ˈpɪnhed/	булавочная головка, քորոց
Pharmaceutical, adj	/ˌfɑː.məˈsuː.tɪ.kəl/	фармацевтический, դեղագործական
Predict, v	/prɪˈdɪkt/	предсказывать, կանխատեսել
Property, n	/ˈprɒpəti/	свойство, հատկություն
Protection, n	/prəˈtekʃn/	защита, պաշտպանություն
Respond, v	/rɪˈspɒnd/	отвечать, պատասխանել
Scale, n	/skeɪl/	шкала, սանդղակ, մասշտաբ
Side effects		побочные эффекты, կողմնակի ազդեցություն
Significantly, adv	/sɪɡˈnɪfɪkəntli/	существенно, զգալիորեն
Simultaneously, adv	/ˌsɪmlˈteɪniəsli/	одновременно, միաժամանակ
Strand, n	/strænd/	прядь, нитка, թել
stained glass window		витражное окно, վիտրաժային պատուհան
Steel, n	/stiːl/	сталь, պողպատ
Tiny, adj	/ˈtaɪni/	крошечный, փոքրիկ

Unique, adj	/juˈniːk/	уникальный, եզակի, ունիկալ
Width, n	/wɪdθ/	ширина, լայնություն

Ex. II. Answer the questions on the text:

1. What is nanotechnology?
2. What is the size of nanomaterials?
3. When did the idea of nanotechnology first appear?
4. How are the names of Richard Feynman and Eric Drexler connected with the development of nanotechnology?
5. What possibilities does the nanoscale provide?
6. What are the application areas for nanotechnology.

Ex. III. Give Russian/Armenian equivalents for the following words and expressions:

Stained glass window, molecular scale, to contribute to, a handful of, tiny probe, explore the idea, to alter the composition, respond to accusations, fundamental properties of materials, unlimited possibilities, advanced nanotechnology, environmental protection, contaminant neutralization, environmental decontamination, self-heating/cooling clothes, to increase significantly.

Ex. IV. Give English equivalents for the following words and expressions:

Цепь ДНК/ԴՆԹ շղթա, крошечные частицы/փոքրագույն մասնիկներ, читать лекцию/կարդալ դասախոսություն, невероятные устройства/անհավանական սարքավորումներ, отвечать на обвинения/պատասխանել մեղադրանքներին, научная фантастика/գիտաֆանտաստիկա, в масштабе/մասշտաբով, неограниченные возможности/անսահմանափակ հնարավորություններ, дезактивация окружающей среды/շրջակա միջավայրի ախտահանում:

Ex. V. Match the verbs from A with the most suitable word(s) from B.

A	B
1. to manipulate	a) medical imaging
2. to make use of	b) cancer therapies
3. to give	c) matter
4. to explore	d) chemical composition
5. to popularize	e) accusations
6. to build	f) unlimited possibilities
7. to describe	g) the word ‘nanotechnology’
8. to respond to	h) machines
9. to alter	i) a lecture
10. to control	h) a scanning tunneling microscope
11. to create	k) the idea
12. to aid in	l) unusual properties
13. to contribute to	m) materials

Grammar exercises

Rewrite the sentences (a-g) following the Complex Subject model in the example. Make use of the verbs in brackets.

Example: Nanotechnology will impact a broad range of fields, from basic science to consumer goods. (assume). Nanotechnology is assumed to impact a broad range of fields, from basic science to consumer goods.

1) Nanoscale science will be as important as steam engine, the transistor and the Internet. (believe)
2) Nanotechnology will revolutionize essentially all manufactured products, from computers to medical instruments to solar cells to planes and rockets. (expect)
3) A technology that lets each individual design and build whatever they want will not be compatible with centralized control. (appear)
4) Many areas of biomedicine will benefit from nanotechnology. (consider)
5) Molecular scale positional devices will resemble very small versions of their everyday macroscopic counterparts. (be likely)
6) Self-cleaning or 'easy-to-clean' surfaces on ceramics and glasses will be the most prominent application of nanotechnology in the household appliances. (prove)
7) Nanotechnology will make medical services much more inexpensive as well as much more effective. (think).

Ex. VI. Translate the following sentences from English into Russian/Armenian:

1. In future nanotechnology is claimed to be able to manipulate molecules and create tiny computers or nanobots that will fuse with our bodies.
2. Potential applications of nanotechnology are likely to bring about more change in 25 years than the entire 20th century.
3. Advanced nanotechnology, or that which works with artificial intelligence, nanorobots and selfassembly, is supposed to increase significantly.
4. Self-replicating machines are certain to run out of control and consume everything available.
5. Bio-compatible, high-performance materials are promised to be created for use in artificial implants.
6. Water-and-stain repellent and wrinkle-free clothes are reported to be produced with the use of nanofiber.

READING 2.

THE RISE OF NANOTECHNOLOGY

Will nanotechnology change human life in ways never thought possible? Is nanotechnology the key that will unlock the door to the next Industrial Revolution? The current debate around this field of science is frequently polarized into two opposing camps. On the one hand there are scientists, engineers and investors who are keen to promote the field as a source of new products and processes. They promise that these will lead to changes as revolutionary as those caused by the explosion of information and communications technologies in recent decades. On the other hand there are environmentalist critics and others who warn that the potential hazards of nanotechnology remain unknown, some even demanding a moratorium on new developments in the area. So, what are some of the bright-side manifestations of nanotechnology?

- Cancer cells could be destroyed by silicon combs; "nanobots" could clear blocked blood vessels; bio-compatible, high-performance materials could be created for use in artificial implants.
- The use of nanofibers would make clothes water and stain repellent or wrinkle- free and would guarantee full-surface protection from electrostatic charges for the wearer; military application could be in camouflage where nanocameras mixed with nanodisplays could create an "invisibility coat", acting like the skin of a chameleon.
- Mass storage devices would be built that can store more than a hundred billion billion bytes in a volume the size of a sugar cube; and parallel computers of the same size that can deliver a billion billion instructions per second.
- Microscopic solar cells in building facades and on road surfaces would produce cheap energy; nanotechnology would cut costs both of the solar cells and the equipment needed to deploy them, making solar power economical and moving it into the mainstream.

➢ Nanotechnology would dramatically reduce the costs and increase the capabilities of space ships and space flight; travel in space would no longer be reserved for an elite few. And many more… But at scales of a millionth of a millimeter, materials can develop unusual and unpredictable properties, leading to concerns about risks to health and the environment. So, what are the possible downsides of this new technology?

➢ Rapid and inexpensive manufacture of advanced weapons could also be developed quickly; an arms race based on this technology could destabilize existing power structures in unpredictable ways.

➢ Criminal technologies, from weapons to spy systems to communication to smuggling, would get a boost from the ability to fabricate advanced products as needed; criminals and terrorists with stronger, more powerful, and much more compact devices could do serious damage to society.

➢ Molecular manufacturing would allow the creation of very small, inexpensive supercomputers that could run a programme of constant surveillance on everyone. There might be attempts of introducing round-the-clock surveillance of every citizen.

➢ Self-replicating nanomachines could run out of control and reproduce so exponentially that they could consume everything available and turn terrestrial life into mush or "grey goo". These ideas barely scratch the surface of what is possible. In any case, there is no sense in elaborating on frightening scenarios that are as misleading as naïve promises that 'the whole thing is harmless'. It would be more effective for the development of this new technology to be accompanied by education and critical examination.

Answer the questions:

a) Is the advent of nanotechnology welcome by everyone? Why? Why not?

b) What spheres of our life could benefit from nanotechnology applications?

c) What are the main concerns about the future widespread use of nanotechnology?

SPEAKING

1. Work in teams. Discuss your arguments "for" and "against" nanotechnology.

Team A
You support the idea that nanotechnology will only change our life for better. You think that people, who speak about risks and dangers connected with nanotechnology, exaggerate the problem.

Team B
You admit that nanotechnology might bring lots of benefits. Still you are afraid that such benefits would be outweighed by different hazards brought about by nanotechnology.

Functional language

Agreeing and disagreeing

Opinions – I think (that)…/In my opinion…/As for me…
Agreeing – Absolutely/Right/That's right. I agree/You're right.
Disagreeing – I know, but… /I see your point, but…/I'm not sure…/That's not true…

LISTENING

Scan the QR code, watch the video and answer the questions on the topic:

1. What will happen if you drop a pen?
2. How big is nanometer?
3. What is called quantum effect?
4. Does gravity work at nanoscale?
5. What is nanoscience about?

Enjoy yourself

A neutron walks into a bar; he asks the bartender, “How much for a beer?”.

The bartender looks at him, and says “For you, no charge”.

UNIT X.

Ex. I. Read the text paying attention to the new vocabulary:

*There was a young lady named **Bright**,*
*Whose speed was far faster than **light**.*
She went out one day,
In a relative way,
And returned the previous night!
Reginald Buller

PARTICLES THAT GO FASTER THAN LIGHT

Since the formulation of the special theory of relativity by Einstein in 1905, physicists have believed that the speed of light in a vacuum is the maximum speed at which energy or information can travel through space.

With the development of subatomic physics, however, the context has changed considerably. We now know that the subatomic particles can easily be created or destroyed and that in their mutual interactions their energies and other properties change discontinuously, rather than in the smooth way envisioned in classical physics. Therefore, one can imagine the creation of particles already traveling faster than light, and so avoid the need for accelerating them through the "light barrier" with the attendant expenditure of infinite energy.

It should be mentioned that there is a third class of particles, including photons (light quanta) and neutrinos, for which the rest mass is zero and which always travel at c.

The possibility therefore seems to exist that there is a new kind of natural object: one that always travels faster than light. In anticipation of the possible discovery of faster-than-light particles, Gerald Feinberg named these particles tachyons, from Greek word tachyons, meaning swift. In order to show how physicists have gone about searching for tachyons, the authors describe some of the properties that would distinguish them from ordinary particles.

There are several properties that would distinguish tachyons from ordinary particles.

1. We have seen that for ordinary particles, as their speed increases, their energy also increases. For tachyons, in contrast, an increase in speed results in a decrease in energy. Hence a tachyon that was losing energy by interacting with matter or by radiating light would speed up, whereas a tachyon that was gaining energy from some outside source would slow down, and its speed would approach c from above rather than below.

2. For ordinary particles the energy is a number whose values will change from observer to observer but that will always be positive. A tachyon whose energy is positive for one observer, however, might appear to be negative to other observers in motion with respect to the first.

3. The number of tachyons in some region of space must vary from observer to observer. Suppose one observer views the process of emission of a tachyon by an atom, with the subsequent escape of the tachyon to infinity. A second observer may view the same process as the tachyon's coming in from outer space and being absorbed by the atom. Hence the two observers will disagree on the number of tachyons present in the past and in the future. Again this situation differs from that for ordinary particles, where the number of particles present at any time is independent of the observer. A detailed theory of the interaction of tachyons with matter, which has not yet been worked out, would have to take these features into account.

Study the basic vocabulary

Word	Transcription	Translation
Absorb, v	/əbˈzɔːb/	поглощать, всасывать, կլանել
Accelerate, v	/əkˈseləreɪt/	ускорять, արագացնել
Anticipation, n	/ænˌtɪsɪˈpeɪʃn/	ожидание, предвкушение, սպասելիք
Attendant, adj	/əˈtendənt/	сопутствующий, сопровождающий, ուղեկցող
Avoid, v	/əˈvɔɪd/	избегать, խուսափել
Contradiction, n	/ˌkɒntrəˈdɪkʃn/	противоречие, հակասություն

Consistent, adj	/kənˈsɪstənt/	последовательный, согласованный, հաջորդական
Considerably, adv	/kənˈsɪdərəbli/	значительный, զգալիորեն
Detect, v	/dɪˈtekt/	замечать, обнаруживать, նկատել
Destroy, v	/dɪˈstrɔɪ/	разрушать, уничтожать, ոչնչացնել
Discontinuously, adv	/diskənˈtɪnjuəsli/	прерывисто, ընդհատվող
Distinguish, v	/dɪˈstɪŋgwɪʃ/	различать, տարբերակել
Effort, n	/ˈefət/	попытка, ջանք, աշխատանք
Envision, v	/ɪnˈvɪʒn/	представить, պատկերացնել
Escape, v	/ɪˈskeɪp/	вытекать, улетучиваться, փախչել, ազատվել
Expenditure, n	/ɪkˈspendɪtʃə(r)/	расход, трата, ծախս
Furthermore, adv	/ˌfɜːðəˈmɔː(r)/	кроме того, более того, ավելին
Imply, v	/ɪmˈplaɪ/	подразумевать, намекать, ենթադրել, ակնարկել

Infinite, adj	/ˈɪnfɪnət/	бесконечный, безграничный, անսահման
Interaction, n	/ˌɪntərˈækʃn/	общение, взаимодействие, փոխազդեցություն
Mutual, adj	/ˈmjuːtʃuəl/	взаимный, փոխադարձ
Occur, v	/əˈkɜː(r)/	случаться, происходить, պատահել
Ordinary, adj	/ˈɔːdnri/	обычный, սովորական
Property, n	/ˈprɒpəti/	свойство, հատկանիշ
Require, v	/rɪˈkwaɪə(r)/	требовать, պահանջել
Satisfy, v	/ˈsætɪsfaɪ/	удовлетворять, угождать, բավարարել
Substantial, adj	/səbˈstænʃl/	существенный, значительный, էական
Swift, adj	/swɪft/	быстрый, արագընթաց
Therefore, adv	/ˈðeəfɔː(r)/	поэтому, следовательно, ուստի

Yield, v	/ji:ld/	производить, приносить, արտադրել, տեղի տալ

Ex. II. Answer the questions on the text:

1. What have physicists thought about the speed of light in a vacuum?
2. What kind of statement does Einstein's first article on relativity contain?
3. What is the rest mass?
4. What are imaginary numbers?
5. What properties would distinguish tachyons from ordinary particles?
6. What is the energy for ordinary particles?
7. Does the mass of a body measure its resistance to a change of speed?
8. Can objects with imaginary energy exchange energy with objects having real energy?

Ex. III. Give Russian/Armenian equivalents for the following words and expressions:

It must be stressed, in anticipation of something, to come to the conclusion, a distinguished physicist, to distinguish tachyons from ordinary particles, to have no possibility of existence, with respect to, to satisfy the requirement, expenditure of infinite energy, an imaginary number, to envision, to speed up, to gain energy, to take into account, expenditure of infinite energy.

Ex. IV. Give English equivalents for the following words and expressions:

Давление/ճնշում, предвидеть/կանխատեսել, думать/կարծել, делать вывод/եզրակացնել, различать/տարբերակել, наблюдать/դիտարկել, происходить/առաջանալ, удовлетворять/բավարարել, быстрый/արագ, придавать большое значение/մեծ նշանակություն տալ, в ожидании чего-либо/ակնկալել, սպասել, выдающийся физик/ականավոր ֆիզիկոս, удовлетворительные результаты/բավարարող արդյունքներ:

Ex. V. Correct the false statements:

1. Efforts to detect particles that go faster than light, named tachyons, have already yielded positive results.
2. The basis of Einstein's conclusion was his discovery that the equations of relativity implied that the mass of an object doesn't depend on its speed.
3. Since the mass of a body measures its resistance to a change of speed, when the mass becomes infinite the body can be made to go much faster.
4. Objects with imaginary energy can exchange energy with objects having real energy and hence can affect them.
5. For ordinary objects the rest mass squared is found to be an imaginary number.

6. The rest mass of the faster-than-light particles can be measured directly.
7. Contrary to common belief, the existence of faster-than-light particles would be inconsistent with the theory of relativity.
8. Tachyons, as their speed increases, their energy also increases.
9. The two observers will always agree on the number of tachyons present in the past and in the future.
10. The existence of tachyons does contradict the theory of relativity.

Grammar exercises

1. Change the sentences into Passive Voice.

1. Many people begin new projects in September.
2. You must wash that dress for tomorrow's party.
3. Mum is going to prepare the food.
4. They made shoes in that factory.
5. We will have to examine you again.
6. They had finished preparations by the time the guests arrived.
7. The delegation will meet the visitors at the airport.
8. The boy is eating the cake.
9. They also speak German at EU meetings.

2. Fill in the blanks with the correct passive form of the verb in brackets:

A new sports and athletic centre …… (open) in our town last week. The facility …… (believe) to be one of the largest in the country and experts hope that it …… (visit) by thousands of amateur and professional athletes over the course of the next few years. The centre …… (construct) for over 6 years before it …… (open) by local authorities last Monday. However, it …… (not completely finish) yet. Workers are making the final adjustments this week and say that it …… (complete) by the end of the month. The centre offers various sports facilities including two indoor swimming pools, three large gyms and a ball court. They …… (can book) online or directly at the administration desk. The equipment ….. (buy) from local companies, which also provided the training programs. The new centre …… (finance) by government funds as well as grants that …… (give) to the region by the European Union. Politicians and famous athletes from all over the country …… (invite) to the official opening ceremony, scheduled for next Tuesday.

READING 2.

Read the text and render the main information.

Traveling faster than light and time-travel could be real for tachyons. If one thing science fiction excels at, it's allowing us to marvel at the breaking of the physical laws of the universe. Tachyons are one of the most interesting elements arising from Einstein's theory of special relativity. The 1905 theory is based on two postulates, nothing with mass moves faster than the speed of light (*c*), and physical laws remain the same in all non-inertial reference frames. A significant consequence of special relativity is the fact that space and time are united into a single entity - spacetime. That means a particle's journey through speed is linked to its journey through time. Aside from the fact that like other particles, they are likely incomprehensibly tiny, because tachyons always travel faster than light it isn't possible to detect one on its approach. That's because it's moving faster than any associated photons.

After it passes, an observer would see the image of the tachyon split into two distinct images. These would show it simultaneously arriving in one direction and disappearing in the opposite direction. If detecting tachyons, at least of their approach, with light is out of the picture, is there another way we could detect these faster than light particles? Possibly. Tachyons are proposed to have an "anti-mass" but this still constitutes mass energy. That means these particles should still have some gravitational effect. It's possible highly sensitive detectors could spot this effect.

An alternative detection method could arise from their faster-than-light nature. While the speed of light in a vacuum *c* is a universal speed limit, particles have been made to travel faster than light in other mediums. When electrically charged particles are accelerated up to and beyond the speed of light in certain mediums like water, they release a form of radiation called Cherenkov radiation, according to the International Atomic Energy Agency. That means that if tachyons are electrically charged, one way of detecting them would be measuring Cherenkov radiation in the near-vacuum of space. What tachyons really demonstrate is the importance of imagination in our ongoing quest to understand the universe. They may not exist, and if they do we may have no hope of ever measuring one. But what our technology can't capture, our minds can. We can consider the possibility of a particle that journeys back through time and what that says about the nature of time, and the Universe, and the events that fill them.

In an interview with George Sylvester Viereck published in "The Saturday Evening Post" in 1929, Albert Einstein is believed to have said: "Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world."

Ex.VI. Translate the following sentences from Russian/Armenian into English:

1. Нам необходимо сделать первые шаги к пониманию этого явления.

Այդ երևույթը հասկանալու համար մեզ անհրաժեշտ է կատարել առաջին քայլերը։

2. Вам следовало бы определить ускорение.

Ձեզ անհրաժեշտ էր սահմանել արագացումը։

3. Для того чтобы объяснить это явление, мы вовлекаем понятие инерции.

Մենք ներառում ենք իներցիայի գաղափարը, որպեսզի բացատրենք այդ երևույթը։

4. Известно, что эти вещества имеют одни и те же свойства.

Հայտնի է, որ այդ նյութերն ունեն միննույն առանձնահատկությունները։

5. Оказалось, что поведение частиц в этих условиях резко меняется.

Պարզվեց, որ մասնիկների վարքագիծը նման պայմաններում կտրուկ փոխվում է։

LISTENING

Scan the QR code, watch the video and answer the questions on the topic:

1. Which particles travel faster than speed of light according to Einstein’s theory?
2. What particles are tachyons?
3. What is a tachyon condensation?
4. What are the properties of a tachyon?

Enjoy yourself

The police officer asks “Sir, do you have any idea how fast you were going?”
The quantum physicist responds “No, but I know exactly where I am”

PART II

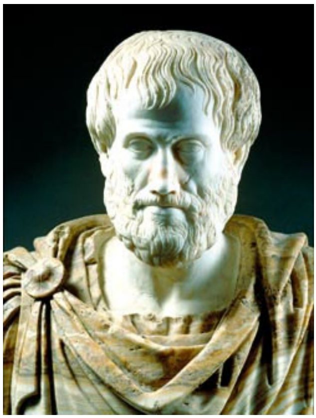
Supplementary Reading

GREAT MINDS IN THE HISTORY OF PHYSICS

1. Remember how to pronounce the names of some well-known scientists.

Archimedes	[ˌɑːkɪ'miːdiːz]	Isaac Newton	['aɪzək 'njuːt(ə)n]
Socrates	['sɒkrətiːz]	James Maxwell	[ʤeɪmz 'mækswel]
Plato	['pleɪtəu]	Michael Faraday	['maɪk(ə)l 'farədeɪ]
Aristotle	['arɪstɒt(ə)l]	Wilhelm Roentgen	[ˈvɪlhelm 'rəntgən]
Ptolemy	['tɒlɪmɪ]	Ernest Rutherford	[' ɜːnɪst 'rʌðəfəd]
Nicolaus Copernicus	['nɪk(ə)ləs kə'pɜːnɪkəs]	Albert Einstein	['ælbət 'ʌɪnstʌɪn]
Johannes Kepler	[ʤəu'hæniːs 'keplə]	Max Plank	[mæks plaːŋk]
Galileo Galilei	[ˌgælɪ 'leɪəʊ 'gælɪleɪ]	Stephen Hawking	[' stiːvən 'hoːkɪŋ]

ARISTOTEL

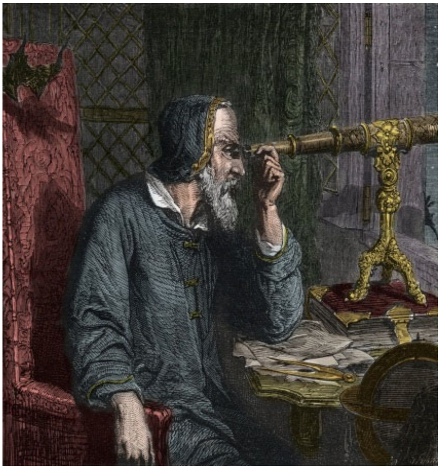


Aristotelian physics is the form of natural science described in the works of the Greek philosopher Aristotle (384–322 BC). In his work *Physics*, Aristotle intended to establish general principles of change that govern all natural bodies, both living and inanimate, celestial and terrestrial – including all motion, quantitative change, qualitative change, and substantial change or "passing away". To Aristotle, "physics" was a broad field that included subjects that would now be called the philosophy of mind, sensory experience, memory, anatomy and biology.

Key concepts of Aristotelian physics include the structuring of the cosmos into concentric spheres, with the Earth at the centre and celestial spheres around it. The terrestrial sphere was made of four elements, namely earth, air, fire, and water, subject to change and decay. The celestial spheres were made of a fifth element, an unchangeable aether. Objects made of these elements have natural motions: those of earth and water tend to fall; those of air and fire, to rise. The speed of such motion depends on their weights and the density of the medium. Aristotle argued that a vacuum could not exist as speeds would become infinite.

Aristotle described four causes or explanations of change as seen on earth: the material, formal, efficient, and final causes of things. As regards living things, Aristotle's biology relied on observation of natural kinds, both the basic kinds and the groups to which these belonged. He did not conduct experiments in the modern sense, but relied on amassing data, observational procedures such as dissection, and making hypotheses about relationships between measurable quantities such as body size and lifespan.

GALILEO GALILEI



Galileo was born in Pisa, Italy on 15 February 1564, the first of six children.

Galileo, though not the first inventor of the refracting telescope, significantly enhanced its power. In 1609, he learned of the spyglass and began to experiment with telescope-making, grinding and polishing his own lenses. His telescope allowed him to see with a magnification of eight or nine times, making it possible to see that the Moon had mountains and that Jupiter had satellites.

He discovered...

1. Craters and mountains on the Moon

The Moon’s surface was not smooth and perfect as received wisdom had claimed but rough, with mountains and craters whose shadows changed with the position of the Sun. Galileo was able to use the length of the shadows to estimate the height of the lunar mountains, showing that they were similar to mountains on Earth.

2.The phases of Venus

The planet Venus showed changing crescent phases like those of the Moon, but their geometry could only be explained if Venus was moving around the Sun rather than the Earth. This undermined the idea that everything in the heavens revolved around the Earth (although it was consistent with the Tychonic system as well as the Copernican one).

3. Jupiter's moons

The planet Jupiter was accompanied by four tiny satellites which moved around it. These are now known as the Galilean moons: Io, Ganymede, Europa and Callisto. Again, this showed that not everything in the heavens revolved around the Earth.

4. The stars of the Milky Way

Galileo saw that the Milky Way was not just a band of misty light, it was made up of thousands of individual stars.

If that wasn’t enough, as well as Galileo’s contributions to astronomy, he also designed a major component for the first pendulum clock, Galileo’s escapement. This design, however, went unbuilt until after the construction of the first working pendulum clock by Christiaan Huygens.

BLAISE PASCAL

Blaise Pascal was born in Clermont, France on June 19, 1623. His mother died when he was only three years old, and he was raised and cared for by his father and two sisters. Pascal's father, Étienne, was an accomplished mathematician and tax collector who took it on himself to educate his son entirely on his own. Étienne decided that Blaise would not be allowed to learn geometry until after he was 15 believing that math, being such a fulfilling subject, would deter his son from his other studies. Blaise took an interest in math on his own, and independently discovered that the sum of the interior angles of all triangles was 180 degrees. When his father saw Pascal's ability and interest in geometry, he gave his son a copy of *Euclid's Elements* and allowed him to study math. Young Pascal joined his father to attend meetings of leading French mathematicians headed by Marin Mersenne, known for his work with prime numbers. At 16, Pascal wrote and presented a paper on conic sections stating that if a hexagon is inscribed in a circle, then the three intersection points of opposite sides lie on a single line. This is known as **Pascal's Theorem**. Pascal is credited with several important inventions and discoveries in math and physics Pascal suffered from poor health for most of his life and died at the early age of 39 on August 19, 1662.

Pascal created one of the first **digital calculators** in 1645 to help his father with collecting taxes. The **Pascaline** used dials, gears and pins to perform multi-digit addition, subtraction, multiplication, and division operations. Pascal earned a patent from King Louis XIV to produce and sell his calculator, but less than 50 prototypes were ever produced.

Pascal conducted groundbreaking experiments with **atmospheric pressure** and fluid dynamics. Using several mercury barometers, Pascal showed that atmospheric pressure decreased at higher altitudes and deduced that above the atmosphere a vacuum existed. Rene Descartes met with Pascal in 1647 to discuss Pascal's experiments with atmospheric pressure. Descartes, along with many other scientists of the period, did not believe in the presence of a vacuum and dismissed much of Pascal's work. Pascal went on to use his experiments to prove the existence of a vacuum and his name is used as a unit of pressure. A **Pascal (Pa)** is equal to one Newton (N) of pressure per meter squared ($1\ Pa = 1\ N/m^2$). In 1650, Pascal's work in fluid dynamics led to his creation of an early **syringe** and the **hydraulic press**. **Pascal's Law** states that pressure exerted anywhere in a confined fluid is transmitted equally in all directions regardless of the shape of the container. This principle explains the liquid mechanical advantage behind the hydraulic press, hydraulic lifts, and hydraulic brakes.

Pascal is also credited with the invention of the **roulette wheel**, used for gambling around the world today. Pascal's wheel was the result of his failed efforts in 1655 to create a perpetual motion machine.

ISAAC NEWTON

Isaac Newton, the man of powerful mathematical ability, was born into a family of a farmer in 1642, the year Galileo died. The early days of Isaac's life were rather unhappy. The child was so weak and slow-witted that his grandmother had pity on him and didn't send him to school till the boy was twelve. While at school and later at Cambridge Newton studied with no particular distinction, though he was extremely skillful in making models, intricate mechanical toys, sunclocks and so on.

His first "tutor" in science and the man who impressed Isaac most by his great charm and popularity was Descartes, who died when Newton was eight years old. Descartes' powerful imagination had enabled him to write not only serious scientific papers but a great number of popular scientific books and even science-fiction novels. In his serious scientific papers Descartes was able to concentrate the most advanced scientific papers but a great number of popular scientific ideas of his time widely ranging from philosophy to many fields of exact sciences including physics. In his fancy-novels the features of real and imaginable worlds were so fantastically interconnected that Isaac Newton was completely carried away by this brilliant, charming, powerfully clever and so popular Frenchman in those years. Descartes' influence on Newton can be felt in all the latter's works and through all his life. As to scientific ideas it was much later, that Newton understood the weakness of Descartes' approach to solution of specific problems.

Newton was personally an extremely odd character, very reserved and even secretive. He never married. He knew enough to make him very self-critical, but this made him even more resentful of the criticism of other people. In 1684, Halley, Newton's friend, offered a prize for the solution of the celestial body motion problem. Many men led up to it, but only one had the genius to find the answer to it. That genius was Isaac Newton who had attracted little notice of before that.

CHARLES COULOMB

Coulomb is most famous for his work with electricity and magnetism. His studies and papers were the first thorough accounts of how electricity worked and its relationship to magnetism.

In 1777, Coulomb understood that a needle on a pin creates friction and reduces accuracy. Coulomb replaced the fulcrum with a fine silk thread, and rather than the up-and-down motion of the pan balance, he used a twist or torsion around this thread. He was able to show that the amount of torsion is proportional to the amount of force.

Between 1785 and 1789, Coulomb studied the force of charges through precise experiments at the Royal Academy and published numerous papers on his findings. In 1785, Coulomb presented three papers on electricity and magnetism. These papers led Coulomb to the law that would eventually bear his name, Coulomb's law. Coulomb's law was the first dealing with a quantitative analysis of electricity.

In his first paper, Coulomb describes the technique to construct his torsion balance, and the properties of the metal wires of having a reaction torsion force proportional to the torsion angle.' In this paper, Coulomb derived the law *two bodies electrified of the same kind of electricity exert a repulsive force on each other.*

In this publication, Coulomb describes the attractive force between two oppositely-charged objects. The force is proportional to the product of the quantities of charge on the objects and inversely proportional to the square of the distance between the objects.

In his second paper, Coulomb describes the loss of electricity that an isolated body loses over time.

Coulomb's law states that in a vacuum, the force between two stationary point charges is inversely proportional to the square of the distance. The power is proportional to the product of the force in the direction in which connected. Charges of the same sign repel, while opposite charge attract.

GEORG OHM

Georg Simon Ohm was a German physicist, best known for his "Ohm's Law", which states that the current flow through a conductor is directly proportional to the potential difference (voltage) and inversely proportional to the resistance. The physical unit of electrical resistance, the Ohm (symbol: Ω), was named after him. Born on March 16 in 1789 in the university town of Erlangen, Bavaria, his younger brother Martin Ohm also became a famous mathematician. His father, Johann Wolfgang Ohm, was a locksmith and his mother Maria Elizabeth Beck, who died when Georg was ten years old, was the daughter of a tailor. Johann Ohm taught his children science and mathematics at home and Georg also attended Erlangen Gymnasium for four years. In 1805, at the age of fifteen Georg Ohm began studying at Erlangen University but he left after three semesters having spent much of his time enjoying himself dancing, ice skating and playing billiards and too little time on his studies. Ohm was then sent to Switzerland in 1806, accepting a position as a mathematics teacher in a school in Gottstadt. While teaching in Cologne, Ohm started passionately working on the conductivity of metals and the behavior of electrical circuits.

After extensive research, he wrote “Die Galvanische Kette, Mathematisch Bearbeitet” (The Galvanic Circuit Investigated Mathematically) in 1827, which formulated the relationship between voltage (potential difference), current and resistance in an electrical circuit: $I = V / R$

Ohms Law states that the current flow through a conductor is directly proportional to the potential difference (voltage) and inversely proportional to the resistance.

After initial criticism, most particularly by Georg Hegel, the noted creator of German Idealism, who rejected the authenticity of the experimental approach of Ohm, the “glory” finally came in 1841 when the Royal Society of London honored him with the Copley Medal for his extraordinary efforts. Several German scholars, including an adviser to the State on the development of telegraph, also recognized Ohm’s work a few months later.

The pertinence of Ohm’s Law was eventually recognized. The law still remains the most widely used and appreciated of all the rules relating to the behavior of electrical circuits. He received the Royal Society Copley medal in 1841.

Georg Ohm was made a foreign member of the Royal Society in 1842, and became a full member of the Bavarian Academy of Sciences and Humanities in 1845.

Ohm died on July 6, 1854. He was 65 years old. The physical unit of electrical resistance, the Ohm (symbol: Ω), was named in his honor.

MICHAEL FARADAY

A self-educated man with a brilliant mind, Michael Faraday was born in a hardscrabble neighborhood in London.

Faraday was one of four children, all of whom barely had enough to eat. His formal education was curtailed by a dramatic incident in the classroom. The prevailing educational philosophy of the day was, “spare the whip, spoil the child”, and that attitude, combined with a speech impediment, led to the school master one day beating young Michael so severely that he could not move off the classroom floor. The brutal event turned out to be his final day in school, as his mother decided he would leave public education forever.

At age 13, he got a job in a bookbinding shop, reading every book on which he worked. He developed special interest in science, particularly in electricity and magnetism. Faraday soon turned his home into a lab, teaching himself the fundamentals of chemistry and physics. In one of his first experiments, he fashioned a crude electrostatic generator using old bottles and pieces of wood.

The visionary scientist received his first big break when fellow countryman Sir Humphry Davy, one of the greatest scientific minds of the time, invited him to lectures on chemicals. Faraday was so moved by the experience that he made a bound copy of his notes and had them delivered to Davy in the hope of securing employment. Eventually, Faraday was hired as a laboratory assistant and learned chemistry at the side of one of the greatest scientists of the era. Taking full advantage of the break he had been given, he impressed Davy and his staff with his eager, yet humble, manner, and Farady's career began to flourish.

He helped advance development of the battery by showing that layers of sheets of zinc amidst other chemicals could produce an electric charge. Other breakthroughs occurred when Faraday found the motion of a magnet inside a wire coil could produce electricity. All of this was a precursor to his discovery of electromagnetic induction: the use of an electromagnetic effect on a charged wire to generate power in an alternate wire. His findings in this area would later be the basis for the electric transformer, a device that produces a consistent electric current, also known as magneto-electric induction. To achieve that steady stream of electricity, Faraday created the first generator by spinning a copper disc between the opposite poles of a horseshoe magnet.

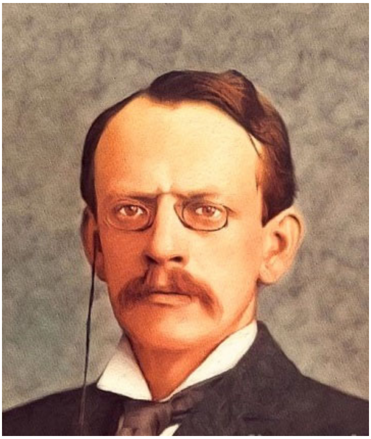
These developments evolved into the electric motors, generators and transformers in use today. Some of his later work involved the relationship between magnetism and light.

Faraday is considered one of the most influential scientists, and perhaps the finest experimentalist, in history. As a measure of his influence, consider that many analytical terms bear his name. In addition to the aforementioned "Faraday effect", they include the unit of capacitance, known as the farad, as well as the Faraday constant, the charge on a group of electrons.

JAMES MAXWELL

James Clerk Maxwell, (born June 13, 1831, Edinburgh, Scotland. Died November 5, 1879, Cambridge, Cambridgeshire, England), Scottish physicist best known for his formulation of electromagnetic theory. He is regarded by most modern physicists as the scientist of the 19th century who had the greatest influence on 20th-century physics, and he is ranked with Sir Isaac Newton and Albert Einstein for the fundamental nature of his contributions. In 1931, on the 100th anniversary of Maxwell's birth, Einstein described the change in the conception of reality in physics that resulted from Maxwell's work as "the most profound and the most fruitful that physics has experienced since the time of Newton."

The concept of electromagnetic radiation originated with Maxwell, and his field equations, based on Michael Faraday's observations of the electric and magnetic lines of force, paved the way for Einstein's special theory of relativity, which established the equivalence of mass and energy. Maxwell's ideas also ushered in the other major innovation of 20th-century physics, the quantum theory. His description of electromagnetic radiation led to the development (according to classical theory) of the ultimately unsatisfactory law of heat radiation, which prompted Max Planck's formulation of the quantum hypothesis, i.e., the theory that radiant-heat energy is emitted only in finite amounts, or quanta. The interaction between electromagnetic radiation and matter, integral to Planck's hypothesis, in turn has played a central role in the development of the theory of the structure of atoms and molecules.



J.J. THOMSON

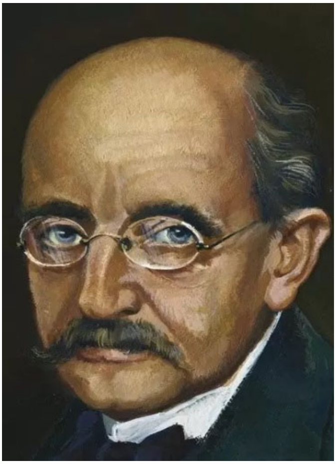
Joseph John Thomson was born in Cheetham Hill, a suburb of Manchester on December 18, 1856. He enrolled at Owens College, Manchester, in 1870, and in 1876 entered Trinity College, Cambridge as a minor scholar. He became a Fellow of Trinity College in 1880, when he was Second Wrangler and Second Smith's Prizeman, and he remained a member of the College for the rest of his life, becoming Lecturer in 1883 and Master in 1918. He was Cavendish Professor of Experimental Physics at Cambridge, where he succeeded Lord Rayleigh, from 1884 to 1918 and Honorary Professor of Physics, Cambridge and Royal Institution, London.

Thomson's early interest in atomic structure was reflected in his *Treatise on the Motion of Vortex Rings* which won him the Adams Prize in 1884. In 1896, Thomson visited America to give a course of four lectures, which summarised his current researches, at Princeton.

Thomson returned to America in 1904 to deliver six lectures on electricity and matter at Yale University. They contained some important suggestions as to the structure of the atom (plum pudding method). He discovered a method for separating different kinds of atoms and molecules by the use of positive rays, an idea developed by Aston, Dempster and others towards the discovery of many isotopes.

Thomson, a recipient of the Order of Merit, was knighted in 1908. He was elected Fellow of the Royal Society in 1884 and was President during 1916–1920; he received the Royal and Hughes Medals in 1894 and 1902, and the Copley Medal in 1914.

In 1890, he married Rose Elisabeth, daughter of Sir George E. Paget, K.C.B. They had one son, now Sir George Paget Thomson, Emeritus Professor of Physics at London University, who was awarded the Nobel Prize for Physics in 1937, and one daughter.



MAX PLANCK

Max Karl Ernst Ludwig Planck was born in Kiel, Germany, on April 23, 1858, the son of Julius Wilhelm and Emma Planck.

Planck studied at the Universities of Munich and Berlin, where his teachers included Kirchhoff and Helmholtz, and received his doctorate of philosophy at Munich in 1879. Planck's earliest work was on the subject of thermodynamics, an interest he acquired from his studies under Kirchhoff, whom he greatly admired, and very considerably from reading R. Clausius' publications. He published papers on entropy, on thermoelectric ity and on the theory of dilute solutions.

At the same time also the problems of radiation processes engaged his attention and he showed that these were to be considered as electromagnetic in nature. From these studies he was led to the problem of the distribution of energy in the spectrum of full radiation. Experimental observations on the wavelength distribution of the energy emitted by a black body as a function of temperature were at variance with the predictions of classical physics. Planck was able to deduce the relationship between the energy and the frequency of radiation. In a paper published in 1900, he announced his derivation of the relationship: this was based on the revolutionary idea that the energy emitted by a resonator could only take on discrete values or quanta. The energy for a resonator of frequency v is hv where h is a universal constant, now called Planck's constant.

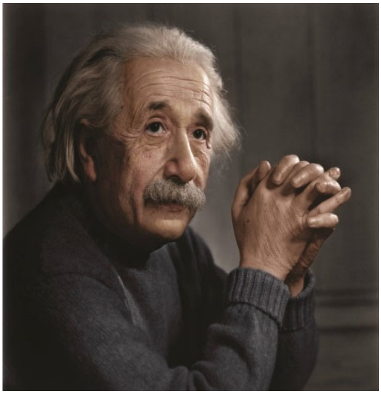
This was not only Planck's most important work but also marked a turning point in the history of physics. The importance of the discovery, with its far-reaching effect on classical physics, was not appreciated at first. However, the evidence for its validity gradually became overwhelming as its application accounted for many discrepancies between observed phenomena and classical theory. Among these applications and developments may be mentioned Einstein's explanation of the photoelectric effect.

Planck faced a troubled and tragic period in his life during the period of the Nazi government in Germany, when he felt it his duty to remain in his country but was openly opposed to some of the Government's policies, particularly as regards the persecution of the Jews. In the last weeks of the war he suffered great hardship after his home was destroyed by bombing.

He was revered by his colleagues not only for the importance of his discoveries but for his great personal qualities. He was also a gifted pianist and is said to have at one time considered music as a career.

Planck was twice married. Upon his appointment, in 1885, to Associate Professor in his native town Kiel he married a friend of his childhood, Marie Merck, who died in 1909. He remarried her cousin Marga von Hösslin. Three of his children died young, leaving him with two sons. He suffered a personal tragedy when one of them was executed for his part in an unsuccessful attempt to assassinate Hitler in 1944. He died at Göttingen on October 4, 1947.

ALBERT EINSTEIN



Considered by many to be the greatest scientist of the twentieth century, Albert Einstein revolutionized scientific thought with new theories of space, time, mass, motion, and gravitation. Born in Ulm, Germany in 1879, Einstein grew up in Munich. Unable to find a teaching job after graduating from a technical institute in Zurich, Switzerland, he accepted a post as an examiner in the Swiss patent office. He worked there from 1902 to 1909, devoting his spare time to his own scientific interests. In 1905 Einstein received his doctorate in physics from the University of Zurich, and published three scientific papers, each of which had a profound effect on the field of physics. The first paper explained the already-observed photoelectric effect - by which beams of light cause metals to release electrons which can be converted into electric current – by suggesting that light be thought of as discrete packets, or quanta, of energy particles. For this work, Einstein in 1921 received the Nobel Prize in Physics. The second paper, on the electrodynamics of moving bodies, put forward Einstein's special theory of relativity and contained the famous equation $E = mc^2$. This equation, which showed that energy and matter are interchangeable, provided the key to the development of atomic energy. The third paper virtually demonstrated the reality of atoms by showing that Brownian motion – the irregular movement of particles suspended in a liquid or a gas - is a consequence of molecular motion.

These papers earned Einstein professorships in Bern, Zurich, and Prague. In 1914 he was appointed director of the Kaiser Wilhelm Institute for Physics in Berlin and offered a professorship at the University of Berlin; two years later, in 1916, he published his epochal paper on gravitational fields, "The Foundation of the General Theory of Relativity." When Hitler and the Nazis came to power in Germany in 1933, Einstein emigrated to the United States, where he joined the newly formed Institute for Advanced Study at Princeton. He became a U.S. citizen in 1940 and died here in 1955. In 1942, after having been naturalized, he was elected to full Academy membership and affiliated with the Academy's Physics Section.

ERNEST RUTHERFORD

Ernest Rutherford (1871–1937) was a New Zealand-born British physicist and recipient of the 1908 Nobel Prize in Chemistry. He is often called the “father of nuclear physics”.

After studying with J. J. Thomson at the Cavendish Laboratory at Cambridge University, Rutherford became a professor and chair of the Physics Department at McGill University in Montreal, Canada. In Montreal, he conducted the research that led to his Nobel Prize, including discovering the principle of radioactive half-lives and separating and naming alpha, beta, and gamma radiation.

In 1907, Rutherford returned to Great Britain to teach at the University of Manchester. Two years later, he, Hans Geiger, and Ernest Marsden conducted the Geiger-Marsden experiment, where they observed alpha particles scattering backwards when fired at a gold foil. The surprising results of this experiment (Rutherford said, “It was as if you fired a 15-

inch shell at a piece of tissue paper and it came back and hit you”) led Rutherford to formulate his model of the atomic nucleus, a revolutionary development in nuclear physics.

In 1919, he became Cavendish Professor of Physics at Cambridge. Rutherford also coined the term “proton” and theorized about the existence of neutrons, which were discovered by his colleague and former student James Chadwick in 1932.

Rutherford had an enormous influence on the field of nuclear physics and mentored many future Nobel Prize winners and prominent scientists, including Chadwick, Niels Bohr and Otto Hahn. He died on October 19, 1937.

ERWIN SCHRÖDINGER

Erwin Schrödinger, (born August 12, 1887, Vienna, Austria – died January 4, 1961, Vienna), Austrian theoretical physicist who contributed to the wave theory of matter and to other fundamentals of quantum mechanics. He shared the 1933 Nobel Prize for Physics with British physicist P.A.M. Dirac. Schrödinger entered the University of Vienna in 1906 and obtained his doctorate in 1910, upon which he accepted a research post at the university's Second Physics Institute.

In 1926, at the age of 39, he produced the papers that gave the foundations of quantum wave mechanics. In those papers he described his partial differential equation that is the basic equation of quantum mechanics and bears the same relation to the mechanics of the atom as Newton's equations of motion bear to planetary astronomy. Adopting a proposal made by Louis de Broglie in 1924 that particles of matter have a dual nature and in some situations act like waves, Schrödinger introduced a theory describing the behaviour of such a system by a wave equation that is now known as the Schrödinger equation. The solutions to Schrödinger's equation, unlike the solutions to Newton's equations, are wave functions that can only be related to the probable occurrence of physical events. The definite and readily visualized sequence of events of the planetary orbits of Newton is, in quantum mechanics, replaced by the more abstract notion of probability.

This aspect of the quantum theory made Schrödinger and several other physicists profoundly unhappy, and he devoted much of his later life to formulating philosophical objections to the generally accepted interpretation of the theory that he had done so much to create. His most famous objection was the 1935 thought experiment that later became known as Schrödinger's cat. A cat is locked in a steel box with a small amount of a radioactive substance such that after one hour there is an equal probability of one atom either decaying or not decaying. If the atom decays, a device smashes a vial of poisonous gas, killing the cat. However, until the box is opened and the atom's wave function collapses, the atom's wave function is in a superposition of two states: decay and non-decay. Thus, the cat is in a superposition of two states: alive and dead. Schrödinger thought this outcome "quite ridiculous," and when and how the fate of the cat is determined has been a subject of much debate among physicists.

In 1927 Schrödinger accepted an invitation to succeed Max Planck, the inventor of the quantum hypothesis, at the University of Berlin, and he joined an extremely distinguished faculty that included Albert Einstein. He remained at the university until 1933, at which time he reached the decision that he could no longer live in a country in which the persecution of Jews had become a national policy. He then began a seven-year odyssey that took him to Austria, Great Britain, Belgium, the Pontifical Academy of Science in Rome, and – finally in 1940 - the Dublin Institute for Advanced Studies, founded under the influence of Premier Eamon de Valera, who had been a mathematician before turning to politics. Schrödinger remained in Ireland for the next 15 years, doing research both in physics and in the philosophy and history of science. During this period he wrote *What Is Life?* (1944), an attempt to show how quantum physics can be used to explain the stability of genetic structure. Although much of what Schrödinger had to say in this book has been modified and amplified by later developments in molecular biology, his book remains one of the most useful and profound introductions to the subject. In 1956 Schrödinger retired and returned to Vienna as professor emeritus at the university.

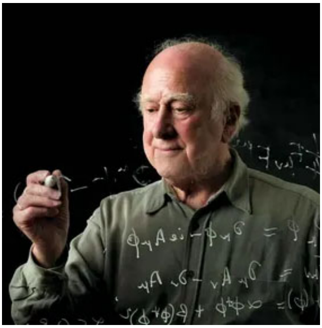
STEPHEN HAWKING

Stephen Hawking (born January 8, 1942, Oxford, Oxfordshire, England – died March 14, 2018, Cambridge, Cambridgeshire), English theoretical physicist whose theory of exploding black holes drew upon both relativity theory and quantum mechanics. He also worked with space-time singularities.

Hawking studied physics at University College, Oxford (B.A., 1962), and Trinity Hall, Cambridge (Ph.D., 1966). He was elected a research fellow at Gonville and Caius College at Cambridge. In the early 1960s Hawking contracted amyotrophic lateral sclerosis, an incurable degenerative neuromuscular disease. He continued to work despite the disease's progressively disabling effects.

Hawking worked primarily in the field of general relativity and particularly on the physics of black holes. In 1971 he suggested the formation, following the big bang, of numerous objects containing as much as one billion tons of mass but occupying only the space of a proton. These objects, called mini black holes, are unique in that their immense mass and gravity require that they be ruled by the laws of relativity, while their minute size requires that the laws of quantum mechanics apply to them also. In 1974 Hawking proposed that, in accordance with the predictions of quantum theory, black holes emit subatomic particles until they exhaust their energy and finally explode. Hawking’s work greatly spurred efforts to theoretically delineate the properties of black holes, objects about which it was previously thought that nothing could be known. His work was also important because it showed these properties’ relationship to the laws of classical thermodynamics and quantum mechanics.

Hawking’s contributions to physics earned him many exceptional honours. In 1974 the Royal Society elected him one of its youngest fellows. He became professor of gravitational physics at Cambridge in 1977, and in 1979 he was appointed to Cambridge’s Lucasian professorship of mathematics, a post once held by Isaac Newton. Hawking was made a Commander of the Order of the British Empire (CBE) in 1982 and a Companion of Honour in 1989. He also received the Copley Medal from the Royal Society in 2006 and the U.S. Presidential Medal of Freedom in 2009. In 2008 he accepted a visiting research chair at the Perimeter Institute for Theoretical Physics in Waterloo, Ontario, Canada.



PETER HIGGS

Peter Ware Higgs (born 29 May 1929) is a British theoretical physicist, Emeritus Professor in the University of Edinburgh, and Nobel Prize laureate for his work on the mass of subatomic particles.

In the 1960s, Higgs proposed that broken symmetry in electroweak theory could explain the origin of mass of elementary particles in general and of the W and Z bosons in particular. This so-called Higgs mechanism, which was proposed by several physicists besides Higgs at about the same time, predicts the existence of a new particle, the Higgs boson, the detection of which became one of the great goals of physics. On 4 July 2012, CERN announced the discovery of the boson at the Large Hadron Collider. The Higgs mechanism is generally accepted as an important ingredient in the Standard Model of particle physics, without which certain particles would have no mass.

Higgs has been honoured with a number of awards in recognition of his work, including the 1981 Hughes Medal from the Royal Society; the 1984 Rutherford Medal from the Institute of Physics; the 1997 Dirac Medal and Prize for outstanding contributions to theoretical physics from the Institute of Physics; the 1997 High Energy and Particle Physics Prize by the European Physical Society; the 2004 Wolf Prize in Physics; the 2009 Oskar Klein Memorial Lecture medal from the Royal Swedish Academy of Sciences; the 2010 American Physical Society J. J. Sakurai Prize for Theoretical Particle Physics; and a unique Higgs Medal from the Royal Society of Edinburgh in 2012. The discovery of the Higgs boson prompted fellow physicist Stephen Hawking to note that he thought that Higgs should receive the Nobel Prize in Physics for his work, which he finally did, shared with François Englert in 2013. Higgs was appointed to the Order of the Companions of Honour in the 2013 New Year Honours and in 2015 the Royal Society awarded him the Copley Medal, the world's oldest scientific prize.

WRITING

1. After reading the texts and learning about the early history of physics complete the chart about the forefathers of physics and their achievements:

scientists	accomplishments
Archimedes	measured the density of solid bodies by submerging them in a liquid, etc. ....

2. Go online and find information about a physicist you really admire. Write an essay of 150–200 words about this physicist. Make use of the guidelines:

- family background
- education
- personal qualities and interests
- professional career
- most outstanding scientific achievements

Study help ***Paragraph writing***

A **paragraph** is a group of related sentences that develop an idea.

The main idea is supported by major details that grow out of it.

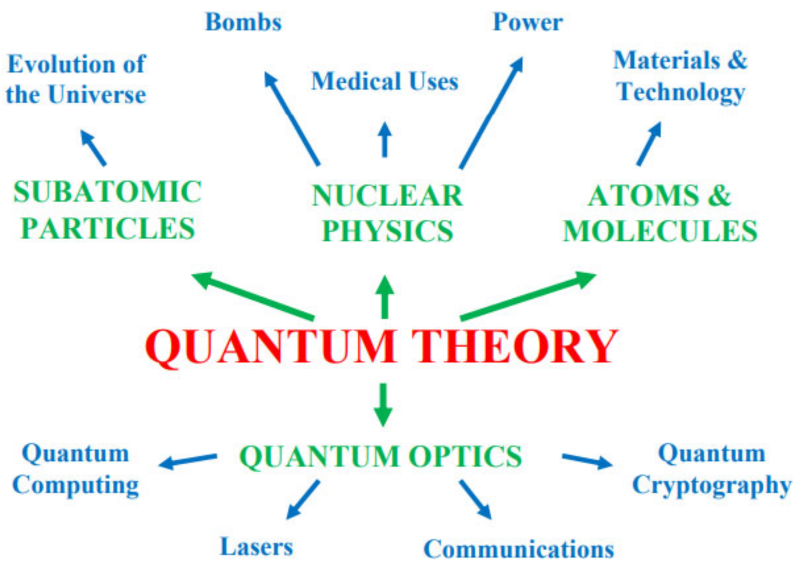
And there are also the so called minor details that grow out of the major ones, i.e. *examples, explanations, additional information*, etc.

When you write, try to join your ideas with the linking words and phrases. When you have finished, re-read and check your work.

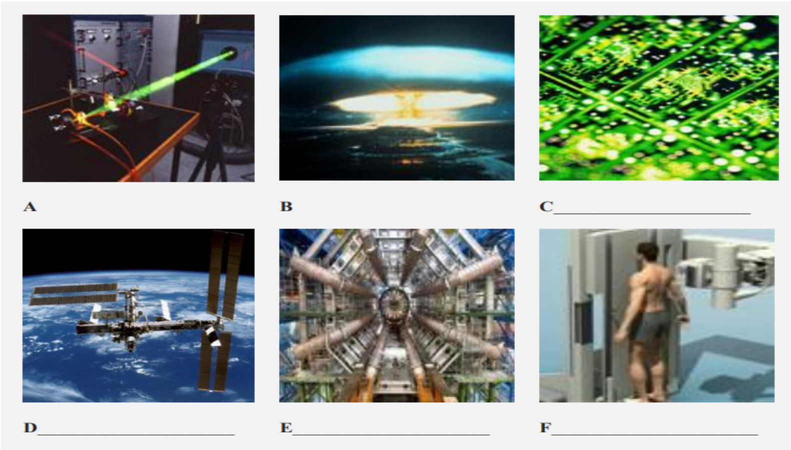
MODERN PHYSICS

Choose one of the fields of physics. Use it as a starting point for your mind map to brainstorm as many branches and areas of application related to this field as you can. Present your mind map to the rest of the class. Explain how the ideas are connected.

Example



Look at the pictures. What kind of invention or discovery do they illustrate? What field(s) of physics does each of them refer to?



Breakthroughs in Quantum Physics

What is quantum physics? Put simply, it's the physics that explains how everything works: the best description we have of the nature of the particles that make up matter and the forces with which they interact.

Quantum physics underlies how atoms work, and so why chemistry and biology work as they do. You, me and the gatepost – at some level at least, we're all dancing to the quantum tune. If you want to explain how electrons move through a computer chip, how photons of light get turned to electrical current in a solar panel or amplify themselves in a laser, or even just how the sun keeps burning, you'll need to use quantum physics.

The difficulty – and, for physicists, the fun – starts here. To begin with, there's no single quantum theory. There's quantum mechanics, the basic mathematical framework that underpins it all, which was first developed in the 1920s by Niels Bohr, Werner Heisenberg, Erwin Schrödinger and others. It characterizes simple things such as how the position or momentum of a single particle or group of few particles changes over time.

But to understand how things work in the real world, quantum mechanics must be combined with other elements of physics – principally, Albert Einstein's special theory of relativity, which explains what happens when things move very fast – to create what are known as quantum field theories.

Three different quantum field theories deal with three of the four fundamental forces by which matter interacts: electromagnetism, which explains how atoms hold together; the strong nuclear force, which explains the stability of the nucleus at the heart of the atom; and the weak nuclear force, which explains why some atoms undergo radioactive decay.

Over the past five decades or so these three theories have been brought together in a ramshackle coalition known as the "standard model" of particle physics. For all the impression that this model is slightly held together with sticky tape, it is the most accurately tested picture of matter's basic working that's ever been devised. Its crowning glory came in 2012 with the discovery of the Higgs boson, the particle that gives all other fundamental particles their mass, whose existence was predicted on the basis of quantum field theories as far back as 1964.

Conventional quantum field theories work well in describing the results of experiments at high-energy particle smashers such as CERN's Large Hadron Collider, where the Higgs was discovered, which probe matter at its smallest scales. But if you want to understand how things work in many less esoteric situations – how electrons move or don't move through a solid material and so make a material a metal, an insulator or a semiconductor, for example – things get even more complex.

The billions upon billions of interactions in these crowded environments require the development of "effective field theories" that gloss over some of the gory details. The difficulty in constructing such theories is why many important questions in solid-state physics remain unresolved – for instance why at low temperatures some materials are superconductors that allow current without electrical resistance, and why we can't get this trick to work at room temperature.

But beneath all these practical problems lies a huge quantum mystery. At a basic level, quantum physics predicts very strange things about how matter works that are completely at odds with how things seem to work in the real world. Quantum particles can behave like particles, located in a single place; or they can act like waves, distributed all over space or in several places at once. How they appear seems to depend on how we choose to measure them, and before we measure they seem to have no definite properties at all – leading us to a fundamental conundrum about the nature of basic reality.

This fuzziness leads to apparent paradoxes such as Schrödinger's cat, in which thanks to an uncertain quantum process a cat is left dead and alive at the same time. But that's not all. Quantum particles also seem to be able to affect each other instantaneously even when they are far away from each other. This truly bamboozling phenomenon is known as entanglement, or, in a phrase coined by Einstein (a great critic of quantum theory), "spooky action at a distance". Such quantum powers are completely foreign to us, yet are the basis of emerging technologies such as ultra-secure quantum cryptography and ultra-powerful quantum computing.

But as to what it all means, no one knows. Some people think we must just accept that quantum physics explains the material world in terms we find impossible to square with our experience in the larger, "classical" world. Others think there must be some better, more intuitive theory out there that we've yet to discover.

In all this, there are several elephants in the room. For a start, there's a fourth fundamental force of nature that so far quantum theory has been unable to explain. Gravity remains the territory of Einstein's general theory of relativity, a firmly non-quantum theory that doesn't even involve particles. Intensive efforts over decades to bring gravity under the quantum umbrella and so explain all of fundamental physics within one "theory of everything" have come to nothing.

Meanwhile cosmological measurements indicate that over 95 per cent of the universe consists of dark matter and dark energy, stuffs for which we currently have no explanation within the standard model, and conundrums such as the extent of the role of quantum physics in the messy workings of life remain unexplained. The world is at some level quantum – but whether quantum physics is the last word about the world remains an open question.

Schrödinger's Cat

Devised in 1935 by the Austrian physicist Erwin Schrödinger, this thought experiment was designed to shine a spotlight on the difficulty with interpreting quantum theory.

Quantum theory is very strange. It says that an object like a particle or an atom that adheres to quantum rules doesn't have a reality that can be pinned down until it is measured. Until then, its properties, such as momentum, are encoded in a mathematical object known as a wave function that essentially says: if you make a measurement, here are a range of possible outcomes. The inevitable question that arose as the theory developed was: what, then, is the thing doing before that?

The most prominent answer in the 1930s came from the Copenhagen interpretation, developed in the Danish city by luminaries of quantum theory, Niels Bohr and Werner Heisenberg. This says that there really is no definitive reality before the measurement, and the object is in an undefined state known as a superposition.

Schrödinger's thought experiment probed how this plays out when a quantum object is coupled to something more familiar. He imagined a box containing a radioactive atom, a vial of poison and a cat. Governed by quantum rules, the radioactive atom can either decay or not at any given moment. There's no telling when the moment will come, but when it does decay, it breaks the vial, releases the poison and kills the cat.

If the Copenhagen interpretation is correct, then before any measurement has occurred, the atom, and so also the cat, are in a superposition of being decayed/dead and not decayed/alive. The absurdity of speaking of a simultaneously living and dead moggie was supposed to show that the Copenhagen interpretation must be lacking something.

The experiment played an important part in spurring other ways of thinking about quantum theory, including the many worlds interpretation, which says that the different possible realities of a quantum object crystallise into different parallel universes at the point of measurement.

These days the thought experiment has taken on a kind of cult status. There are Schrödinger's cat T-shirts, memes and hundreds of articles on the subject. In 2018, scientists published a more complicated variant of the thought experiment that appears to show that all existing interpretations of quantum theory are incomplete.

Quantum Mechanics

Quantum mechanics is the best tool we have to understand how the universe works on its smallest scales.

Everything we can see around us, from far-off galaxies to our own bodies, is made up of subatomic particles, unimaginably tiny entities whose interactions produce the macroscopic effects we experience day-to-day. While it's tempting to imagine that these interactions obey the laws of physics that we're familiar with in our everyday lives, they are actually much stranger.

One of the first physicists to confront this strangeness head-on was Max Planck. In order to explain unusual observations produced when objects were heated to high temperatures, he made a radical assumption. Instead of energy being emitted in a continuous stream, he assumed that there must be some indivisible base unit of energy that could be split no further. In other words, energy could only be exchanged in finite chunks, which he called quanta.

While Planck only came up with this idea in order to simplify his calculations, other physicists rapidly leaped on the real-world implications. Over the coming decades, Albert Einstein, Niels Bohr, Werner Heisenberg, Erwin Schrödinger and others completely restructured the standard picture of reality.

The new picture that emerged showed a world totally unlike the one we knew. A world where objects could travel through walls, particles led parallel lives as waves, and information appeared to be transmitted faster than the speed of light. Many of these apparent paradoxes are so mind-bending as to have entered popular culture. Perhaps most famous is the case of Schrödinger's cat, which imagines a cat trapped in a box that is both dead and alive until somebody bothers to look inside. Small wonder Nobel laureate Richard Feynman supposedly said: “If you think you understand quantum mechanics, you don’t understand quantum mechanics”.

Not that physicists have stopped trying. In their attempts to make sense of quantum weirdness, they have come up with a host of different interpretations of the mathematics at the theory’s heart. As of the time of writing, it remains anyone’s game.

WRITING

Choose one of the discoveries or inventions of modern physics. Write a paragraph about it. Give at least three reasons to prove its significance. Make use of the expressions and the signal words from the Study help box.

It made it possible to .../It helped to...

It was a breakthrough in...

It made a revolution in...

It made an important contribution to...

It gave rise to.../It gave birth to...

It laid the foundation for...

It found widespread application in...

Study help ***Listing***

It is important when reading or writing to recognize and understand the relationship in which sentences and groups of sentences combine to present information.

Here are the signal words that can be used to show the order in which things are to be said.

Firstly	*In the first place*
Secondly	*In addition to*
Also	*What is more*
	Above all

APPENDICES

List of abbreviations, physical constants and international terms frequently used in English scientific and technical literature:

+ plus, a+b=c (a plus b is equal to c) - minus 15-5=10 (fifteen minus five is equal to ten) = equals or is equal to × multiplied by, times a ×b=d (**a** multiplied by **b** equals **d** or **a** times **b** is equal to **d)** a÷b (a divided by b)	b^2 b square a_1 a sub one, a first d_k d sub k n_3 n sub three 10^{-11} ten to the minus eleventh (power) 10^7 ten to the seventh (power) [ ] brackets, square brackets () roundbrackets/ parentheses	$\sqrt[3]{a}$ the cube root of a $\frac{d}{dt}$ d over dt $\frac{dy}{dx}$ dy over dx or the first derivative of y with respect to x $\frac{a+b}{a-b}=\frac{c+d}{c-d}$ a plus b over a minus b is equal to c plus d over c minus d 0.51 0 point five one 0,014 0 point 0 one four

≠ is not equal to a≠b (a is not equal to b) ≤ is less than, a ≤ b (a is less than b) ≥ is greater than, a≥b (a is greater than b)	{ } braces $\sqrt{a}$ the square root of a $\sqrt[n]{a}$ the nth root of a a'' a second prime a' a prime	255,604 two hundred and fifty-five thousand six hundred and four $2\frac{1}{2}$ two and a half $\frac{1}{3}$ one third, a third

Name	Symbol	Value
Atomic Mass Unit/	m_u	1.66053873(13) x 10^{-27} kg
Avogadro's Number/	N_A	6.02214199(47)x $10^{23}$$mol^{-1}$
Bohr Magneton/	μ_B	9.27400899(37)x10^{-24}J T^{-1}
Bohr Radius/	a_o	0.5291772083(19)x10^{-10}m
Boltzmann's Constant/	k	1.3806503(24) x 10^{-23}J K^{-1}
Deuteron Mass/	m_d	3.34358309(26) x10^{-27} kg
Electric Constant/	ε_o	8.854187817 x 10^{-12} F m^{-1}
Electron Mass/	m_e	9.10938188(72) x 10^{-31} kg
Electron-Volt/	eV	1.602176462(63) x 10^{-19} J
Elementary Charge/	e	1.602176462(63) x 10^{-19} C
Faraday Constant/	F	9.64853415(39) x x 10^4 C mol^{-1}
Fine Structure Constant/	α	7.297352533(27) x 10^{-3}
Hartree Energy/	E_h	4.35974381(34) x 10^{-18} J
Hydrogen Ground State/	eV	13.6057
Josephson Constant/	K_j	4.83597898(19) x x 10^{14} Hz V^{-1}
Magnetic Constant/	μ_o	4π x 10^{-7}

Molar Gas Constant/	R	8.314472(15) J K^{-1} mol^{-1}
Natural Unit of Action/	$\hbar$	1.054571596(82) x 10^{-34}J s
Newtonian Constant of Gravitation/	G	6.673(10)x$10^{-11}$$m^3$ kg^{-1} s^{-2}
Neutron Mass/	m_n	1.67492716(13) x 10^{-27} kg
Nuclear Magneton/	μ_n	5.05078317(20) x x 10^{-27}J T^{-1}
Planck Mass/	m_p	2.1767(16) x 10^{-8} kg
Rydberg Constant/	R_H	10 9.73731568549(83) x x 10^5 m^{-1}
Speed of Light in Vacuum/	c	2.99792458 x 10^8 m s^{-1}

SINGULAR	PLURAL
Axis	Axes
Analysis	Analyses
Basis	Bases
Criterion	Criteria
Datum	Data
Equilibrium	Equilibria
Focus	Foci
Formula	Formulae/formulas
Index	Indices/indexes
Locus	Loci
Maximum	Maxima
Minimum	Minima
Medium	Media
Momentum	Momenta
Nucleus	Nuclei
Phenomenon	Phenomena
Quantum	Quanta
Radius	Radii
Spectrum	Spectra
Thesis	Theses

Common Science Prefixes & Suffixes

Prefix	Meaning	Example
A-, An-	without	Asexual, anaerobic
Amphi-	both sides	Amphibian
Auto-	self	Auto-immune
Bi-	two	Biennial
Bio-	life	Biology
Carcin-	cancer	Carcinogen
Circum-	around	Circumference
Di-	two	Dicotyledon
Dia-	across	Diameter
Epi-	upon	Epidermis
Ex-	out	Exoskeleton
Inter-	between	Interstellar
Kine-	move	Kinetic
Macro-	large	Macroscopic
Strat-	layer	Stratosphere

Suffix	Meaning	Example
-arium	place for	Aquarium
-cide	killer of	Pesticide
-cule	very small	Molecule
-en	made of	Wooden
-ist	one who practices	Scientist
-itis	infection	Laryngitis
-let	small	Platelet
-ment	action or process	Experiment

-ology	study of	Biology
-osis	process	Osmosis
-phyll	plant	Chlorophyll
-ize	to make	Synthesize
-oid	resembling	Asteroid
-tude	state of	Amplitude

Latin Abbreviations in English

Abbrev.	Full Form	Meaning
AD	**anno Domini**	since the time of Christ
a.m.	**ante meridiem**	in the morning; before noon
c (*or* **ca**)	**circa**	around; approximately
cf	**confer**	please see ...; refer to ...
e.g.	**exempli gratia**	for example
et al.	**et alii**	and other authors
etc.	**et cetera**	and similar others; and the rest
ff.	**foliis**	and subsequent pages
ibid.	**ibidem**	in the same source
i.e.	**id est**	that is to say; in other words
no.	**numero**	number
op. cit.	**opere citato**	from the earlier-given source
p.m.	**post meridiem**	after noon
q.v.	**quod videre**	check this elsewhere
(sic)	**sic erat scriptum**	so it was written
v. (*or* **vs.**)	**versus**	against; compared to
viz.	**videlicet**	namely

BASIC VOCABULARY OF PHYSICS

Forces and Motion

Acceleration – the rate at which a moving object increases its speed

Aerodynamic – shaped in a way that makes it easier for smth to move through the air smoothly

At rest – not moving

Centre of gravity – the point in an object around which its weight balances

Centrifugal force – a force that makes things move from the centre of smth

Centripetal force – a force that makes things move towards the centre of smth

Circular path – a direction in which smth.is moving that is in shape of a circle

Decelerate – to move more slowly

Efficient – working well and producing good results

Exert – to put force or physical pressure on smth.

External forces – a force that is outside an object and acts on it

First law of motion – one of the laws about movement that were first expressed by Newton

Force – a power that makes an object move or that changes the way it moves

Friction – the force that resists the movement of one object against another

GPS – Global Positioning Satellite

Gravitational pull – the force exerted by gravity, in which things are pulled towards an object

Mass – the amount of matter that smth. contains

Moment – the tendency of a force to produce movement of a load

Newton – a unit for measuring force, equal to the force that causes a mass of one kg to accelerate

Pull – a strong physical force that causes things to move in a particular direction

Push – a movement in which you push someone or something

Resistance – a force that makes a moving object move more slowly

Resultant force – the total force that is acting on an object

Rotate – to move in a circle around a central point

Roughness – the quality of being not smooth

Slide – move smoothly and quickly across a surface

Slow down – reduce the level or amount of speed

Smooth – completely flat

Speed – how fast an object travels

Static friction – the force that prevents stationary objects from moving

Surface – the top layer or outside part of smth.

Turning effect – when a force acts along a line which does not pass through the center of gravity

Twist – to bend or turn in a curved shape

Unstable – likely to change at any time

Weight – a measurement of how heavy smth.is

Weightlessness – the state of having no weight

Energy and Machines

Apply – to use physical force to make smth happen or work

Balancing point – the fixed point on which a lever turns or pivots

Chemical energy – energy that is stored in the chemical structure of a substance

Collision – what happens when two or more objects collide

Conservation – the maintenance of a quantity of smth such as energy or mass at a constant amount

Convert – to change from one thing to another

Distance – the amount of space between two people or things

Effort – the force used on a machine of any type in order to make it able to move an object

Elastic collision – all of the kinetic energy is transferred from one object to another and kinetic energy is not wasted in the form of heat or light

Electrical energy – a type of energy that is carried by very small moving particles

Force multiplier – a system that reduces the force needed to move smth.

Fulcrum – the point on which a lever balances or turns

Gear – a device that consists of rotating wheels with evenly sized and spaced teeth around the edges

Generate – to produce power or heat

Heat – the energy that is produced when the temperature of smth. changes

Inclined plane – a flat surface that forms a slope, making an angle of less than 90 degrees with a horizontal surface

Joule – a unit of measuring work or energy. Symbol J

Kinetic energy – the energy that an object has as a result of moving

Lever – a solid bar, that you put under a heavy object to move it

Lift – the force that makes an aircraft leave the ground and stay in the air

Light energy – energy in the form of light coming mainly from the Sun

Mass energy – mass and energy regarded as interconvertible according to the laws of relativity

Mesh – if parts of an engine or other machine mesh, they connect tightly with each other and work together

Momentum – the tendency of a moving object to keep moving unless another force stops it or slows it down

Nuclear energy – energy that is released during a nuclear reaction

Nuclear fission – the process of splitting the nuclei of particular atoms

Nuclear fusion – the process of combining the nuclei of particular atoms

Pivot – a fixed point or pin that smth. turns on or balances on

Plutonium – a radioactive element that is very toxic and is used in the production of nuclear power

Potential energy – the energy that an object or system has stored because of its position or condition

Reduce – to make smth. smaller or less in size, amount, importance, price

Release – to let a substance or energy spread into the area around it

Rotate – to move in a circle around a fixed point

Run – if a machine or engine is running, it is operating

Solar energy – the energy released by nuclear fusion reactions in stars such as the sun

Sound energy – energy in the form of sound waves

Spiral inclined plane – an inclined plane that has a spiral shape

Split – to divide smth into several parts

Store – to keep smth.in a particular place

Transfer – to move smth. or someone from one place to another

Uranium – a silver-white, radioactive metal element

Velocity – the speed at which smth moves in one direction

Work – the process of changing energy from one form into another

Light and Sight

Angle of incidence – the angle between a ray of light and a line that is perpendicular to a surface, at the point where the ray touches it

Angle of reflection – the angle between a reflected ray of light and a line that is perpendicular to a surface, at the point where the ray is reflected

Beam – a line of light or other form of energy

Bend – to become curved or folded and not straight

Concave – curved inwards

Condensing lens – a lens which makes light rays move towards each other after they hit it

Converging beam – a beam of light in which the rays come together

Convex – a convex surface curves outwards

Demagnifier – smth which makes an image appear smaller

Dim – not bright or clear

Dispersion of light – the separation of a beam of light into several colours

Diverging beam – a beam of light in which the rays spread from a source

Diverging mirror – a mirror that reflects rays of light outwards

Eclipse – a short period when all or part of the Sun or Moon becomes dark, because of the position of the Sun, Moon and Earth

Electromagnetic radiation – light, including light we can see and light we can't see

Filament – the thin wire inside a light bulb

Fluorescent lamp – an electric light that consists of a glass tube with a gas inside and two electrodes at each end

Focal length – the distance from the centre of a lens or mirror to its focal point

Glare – a very bright light that reflects off a surface and makes things difficult to see

Incandescent source – smth that produces light as a result of being made very hot

Incident ray – a ray of light that hits a surface

Inert gas – a gas that does not produce a chemical reaction with other substances

Magnification – the power of a piece of equipment to make smth. appear bigger than it really is

Microwave – a type of electromagnetic wave used in radar

Non-luminous – not producing or reflecting light

Opaque – an opaque substance does not allow light to pass through it

Optical effect – the special way that smth. looks because of the way light is reflected

Optical fibre – a very long thin piece of transparent glass, used in telephone and computer systems for sending information in the form of light

Parallel beam – a beam of light in which the rays are an equal distance from each other

Penumbra – an area covered by the outer part of a shadow, so that it is not completely dark

Photoluminescent material – a material that produces light when a voltage is applied to it

Pupil – the black round part in the centre of the iris of the eye, where light enters

Radio wave – an electromagnetic wave that radio signals can be sent on

Rays – a line of light, heat or energy

Reflected ray – a ray of light that is reflected from a surface

Refraction – the way in which light bends when it passes from one substance to a different substance

Scattered – spread over a large area

Self-luminous – smth. that is self-luminous produces its own light

Speed of light – the speed of light in a vacuum which is equal to $3*10^8$ metres per second

Total internal reflection – a situation that exists when light is refracted so much when it enters a dense medium that is sent backwards

Translucent – a translucent surface is clear enough for light to pass through it, but not completely clear

Transparent – a transparent surface is clear enough to allow a lot of light to pass through it

Ultraviolet – ultraviolet light has waves with shorter wave-lengths than light that humans can see

Umbra – a very dark shadow, sometimes inside an area of lighter shadow

Uniformly – in the same way

Visible spectrum – the seven colours that make up white light

X-ray – a type of dangerous radiation with a very short wavelength that is used for producing images of the inside of things

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