UNIT 2

BUILDING ON HISTORIC SUCCESS

"If I have seen further than others,
it is by standing upon the shoulders of giants."
Isaac Newton

Learning Objectives

In this unit you will:

- ✓ extend vocabulary through synonyms
- ✓ revisit participles
- ✓ make an outline of a text
- ✓ process and summarize information for a talk
- ✓ talk about the history of Physics
- ✓ organize and develop ideas into an essay

LEAD IN

1. **An American teenager addressed the "Ask a Scientist" website with the following question:**

I was wondering, who is/are considered the founder/s of physics? I am doing a presentation in class and have been researching and have not really come up with a specific answer. Who is/are considered the founding father/s of this science?

How would ***you*** answer this question?

2. **Work in groups. Discuss what you know about the history of physics and its founders. Share your ideas with the rest of the class.**

READING

1. **Read the text to learn more about the early history of physics. Complete the chart about the forefathers of physics and their accomplishments.**

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

Historically science has its roots in people's efforts to understand and explain the world and the universe around them. They wanted to feel some degree of control of their lives or at least be able to explain what was going on and why. Their interest was born of concern and fear as well as curiosity. The early history of man involves very little ability to investigate more than could be observed with senses. Many people attributed phenomena they couldn't understand to the presence or actions of gods. Others didn't accept the myths on faith, but chose to investigate further.

The study of mathematics and the sciences, particularly astronomy and physics began in the major centres of ancient civilizations. Alexandria was one of such centres where the mathematician and inventor Archimedes designed various practical mechanical devices, such as levers and screws, and measured the density of solid bodies by submerging them in a liquid.

Some famous Greek philosophers such as Socrates, Plato and Aristotle had a very significant impact on the development of western civilization as a whole and on science in particular. Aristotle viewed the process of learning as one of observation and thinking, but he would not conduct experimentation. Experimentation was not something he supported in his ideas about how to find the answers to questions.

It wasn't until the beginning of the Renaissance that humankind realized that experimentation and observation were equally important. The advent of modern science followed the Renaissance and was inspired

by the highly successful attempt by several outstanding individuals to interpret the behaviour of the heavenly bodies during the 16th and 17th centuries.

The Polish natural philosopher Nicolaus Copernicus introduced the heliocentric system claiming that the planets move around the sun. He was convinced, however, that the planetary orbits were circular.

Some time later after heroic seven-year efforts to more accurately model the motion of the planet Mars, Johannes Kepler concluded that the planets follow not circular but elliptical orbits with the Sun at one focus of the ellipse. This breakthrough overturned a millennium of dogma based on Ptolemy's idea of 'perfect' circular orbits for the 'perfect' heavenly bodies. Kepler also proposed the first known model of planetary motion in which a force emanating from the Sun deflects the planets from their 'natural' motion, causing them to follow curved orbits.

When Galileo Galilei heard of the invention of the telescope, he constructed one of his own in 1609. By observing the phases of the planet Venus he confirmed the heliocentric system. He also discovered the surface irregularities of the moon, the four brightest satellites of Jupiter, sunspots and many stars in the Milky Way. During the early 17th century, Galileo pioneered the use of experimentation to validate physical theories, which is the key idea in modern scientific method. Galileo's interests were not limited to astronomy; he also demonstrated that bodies of different weight fall at the same rate, and that their speed increases uniformly with the time of fall. Galileo's astronomical discoveries and his work in mechanics foreshadowed the work of the 17th century English mathematician and physicist Sir Isaac Newton, one of the greatest scientists who ever lived.

2. Mark the statements *T* for 'true' or *F* for 'false'. Correct the false ones and expand on the true ones.

a) People's fright and desire to have a bit more control of their lives as well as curiosity led to the birth of science. ( )

b) Even in early days people had quite a good ability to carry out experiments and investigations. ( )

c) Alexandria was one of the most important scientific centres of the ancient world. ( )

d) Aristotle thought of experimentation as an important part of any research process. ( )

e) It was Nicolaus Copernicus who suggested that the planets move around the Sun. ( )

f) German astronomer Johannes Kepler came to the conclusion that the planets follow circular orbits. ( )

Study help ***Dealing with True/False statements***

- Read each statement carefully, noting the key words and making sure you understand what is meant by each of them.
- Then skim through the text to see if you can locate a similar or opposite idea.
- The statement can be a paraphrase of some sentence in one paragraph of the text and parts of a sentence in the next paragraph.

g) Galileo constructed the first telescope in the world and with its help observed the phases of the planet Jupiter. ( )

h) Galileo devoted all his research efforts to astronomy. ( )

Focus on language

1. **Find in the text a synonym for each group of words given in the list (*a-j*).**

a) attempt, try, endeavour

b) to research, to study, to observe

c) to connect with, to associate with, to relate to

d) influence, effect , importance

e) arrival, coming, appearance

f) to encourage, motivate, stimulate

g) correctly, exactly, precisely

h) discovery, innovation, development

i) to prove, to provide evidence, to give support to

j) to predict, to foretell, to prognosticate

2. **Find in the text two nouns that collocate with these adjectives.**

a) solid

heavenly

b) planetary

circular

elliptical

curved

Add new vocabulary to your vocabulary notebook. ✍

SPEAKING

Sum up your previous knowledge and facts from the text to give a comprehensive answer to the question of an American teenager about the founding fathers of physics. You may start like this:

"Physics appeared as a separate science only in the early 19th century. Before that time a physicist was often also a philosopher, mathematician, chemist, biologist, engineer, or even a political leader. That's why I do not think that a particular person can be called the forefather of physics. So we can name several outstanding scientists. I would like to start with…"

LISTENING

1. **You are going to listen to a talk about Isaac Newton. Before you listen discuss the following:**

- The poet Alexander Pope once wrote about Newton:

  "Nature and Nature's laws lay hid in night;

  God said, Let Newton be! And all was light."

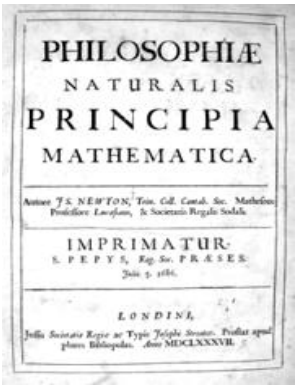
  Was the poet right?
- Which phenomena and laws of nature did Isaac Newton study and explain?
- What is the name of the book in which Newton formulated his famous laws?

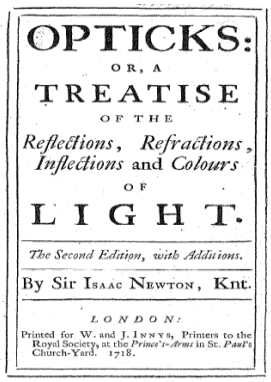
2. **Work in small groups. Brainstorm the most outstanding accomplishments made by Isaac Newton in science and report your ideas to the rest of the class.**

3. **Now, with your list of ideas in front of you, listen carefully to the talk about Newton, marking those that you have predicted.**

4. **Listen again. Make notes under the headings:**

   - **date of birth**
   - **place of birth**
   - **Newton's childhood (family, hobbies, …)**
   - **education**
   - **personal qualities**
   - **Newton's inventions and discoveries**


PHILOSOPHIÆ
NATURALIS
PRINCIPIA
MATHEMATICA
IMPRIMATUR
LONDINI,


OPTICKS:
OR, A
TREATISE
OF THE
Reflections, Refractions, Inflections and *Colours*
OF
LIGHT.
The Second Edition, with Additions.
By Sir Isaac Newton, Knt.
LONDON:
Printed for W. and J. Innys, Printers to the Royal Society, at the *Prince's-Arms* in St. *Paul's* Church-Yard. 1718.

Summarizing

1. **Read the text "История науки"and highlight the Russian equivalents to the English word combinations (1-15).**

1) early 17th century/late 19th century
2) accumulation of knowledge about something
3) a founder of natural science
4) the period of its formation
5) to develop/create a physical structure of the world
6) a complete system of mechanics
7) to challenge Newtonian physics
8) Maxwell's theory of electromagnetic field
9) to lead to revolutionary changes
10) transition period to new/modern physics
11) special theory of relativity
12) quantum theory
13) classical concepts and notions of something
14) to lay the foundation of something
15) quantum-relativistic structure of the world

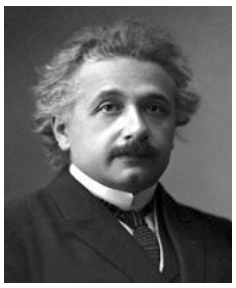
Add new vocabulary to your vocabulary notebook. ✍

История науки

История физики хранит немало событий и фактов, оказавших большое влияние на развитие этой древней науки. Период от древнейших времен до начала XVII в. – это период накопления физических знаний об отдельных явлениях природы.

Физика как наука берет начало от Г. Галилея – основоположника точного естествознания. Период от Г. Галилея до И. Ньютона представляет начальную фазу физики, период ее становления.

Последующий период начинается с работ И. Ньютона, который создал первую физическую картину мира как завершенную систему механики. Созданная И. Ньютоном и его последователями, Л. Эйлером, Ж. Даламбером, Ж. Лагранжем, П. Лапласом и другими, грандиозная система классической физики просуществовала два века и только в конце XIX в. начала рушиться под напором новых фактов, не укладывавшихся в ее рамки. Правда, первый ощутимый удар по физике Ньютона нанесла еще в 60-х годах XIX века теория электромагнитного поля Максвелла – вторая после ньютоновской механики великая физическая теория, дальнейшее развитие которой привело к революционным изменениям в физике. Поэтому период классической физики в принятой схеме делится на три этапа: от И. Ньютона до Дж. Максвелла (1687 – 1859), от Дж. Максвелла до В. Рентгена (1860 – 1894) и от В. Рентгена до А. Эйнштейна (1895 – 1904).



Этап с 1895 по 1904 гг. является периодом революционных открытий и изменений в физике, когда последняя переживала процесс своего преобразования и обновления. Это был период перехода к новой, современной физике, фундамент которой заложили специальная теория относительности и квантовая теория. 1905 год – год создания А. Эйнштейном специальной теории относительности и превращения идеи кванта М. Планка в теорию квантов света. Данные теории ярко продемонстрировали отход от классических представлений и понятий и положили начало созданию новой физической картины мира – квантово-релятивистской.

2. **Read the text again and summarize it in English using the word combinations in Task 1and the phrases for summarizing.**

Focus on language

Participle

There are two types of participles in English: **Participle I** – ***verb+ing*** and **Participle II** (Past Participle) **– *verb+ed / V*3** of irregular verbs.

1) We use **Participle I** to say what somebody (or something) is (or was) doing at a particular time.

e.g.

- *Do you know the student **talking** to Professor Drake?* (the student is talking to the professor)
- *The team of young researchers **studying** this problem is looking for new approaches*. (they are studying the problem)
- *I was awakened by a bell **ringing.*** (a bell was ringing)

2) One can also use **Participle I** to say what happens all the time, not just at a particular time.

e.g.

- *Kepler proposed the first known model of planetary motion in which a force **emanating** from the Sun deflects the planets from their "natural" motion, so they follow curved orbits.*
  (a force constantly emanates from the sun)

3) **Participle II** has a ***passive*** meaning.

e.g.

- *In addition to his scientific work, Pyotr Kapitsa became widely known as a public figure greatly **respected** for his views*. (he was respected by other people)

1. **Complete the sentences (a-h) using the verbs from the box in the correct form.**

radiate	**come out**	**characterize (2)**	**make**	**integrate**
place	**entitle**	**devise**	**interact**	

Example:

- *Newton observed that white light could be separated by a prism into a spectrum of different colors, each **characterized** by a unique refractivity.*
- *Lord Kelvin suggested that the Sun was a gradually cooling liquid body **radiating** an internal store of heat.*

a) Newton's book _____ Philosophae Naturalis Principia Mathematica or Mathematical Principles of Natural Philosophy became a masterpiece of scientific insight.

b) The study of magnetism _____ with the study of electricity by the English physicist Michael Faraday in 1821 was of great importance for the research of electromagnetic fields.

c) Superfluidity is a state of matter _____ by the complete absence of viscosity.

d) It was a prerequisite for the great progress _____ in low-temperature physics.

e) Pyotr Kapitsa proposed a method for determining the magnetic moment of an atom _____ with an inhomogeneous magnetic field.

f) Superfluids _____ in a closed loop can flow endlessly without friction and energy loss.

g) The new vacuum-based theory of inertia _____ by Haisch and his colleagues requires an energy-rich vacuum, which implies a cosmological constant.

h) After months of work Stephen Hawking came up with a remarkable result; he could see radiation (later called Hawking Radiation) _____ of the black hole.

2. **Translate the sentences in Task 1 into Russian. Pay special attention to the translation of the participles in these sentences.**

READING

1. **Answer the questions.**
   - What do you know about the Russian scientist Pyotr L. Kapitsa?
   - To which fields of physics did Kapitsa mostly contribute?

2. **The terms that follow are from the text you are going read. Practise the pronunciation of the terms and give their Russian equivalents.**

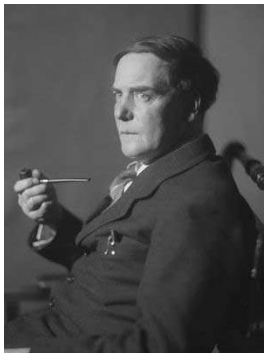
magnetic moment of an atom	[mæg'netɪk 'məumənt əv ən 'ætəm]
inhomogeneous magnetic field	[ˌɪnhɒmə(ʊ)'dʒi:nɪəs mæg'netɪk fi:ld]
to liquefy helium	['lɪkwɪfaɪ 'hi:lɪəm]

cryogenics	[ˌkraɪə'ʤenɪks]
superfluidity in helium	[ˌs(j)uːpəfluː'ɪdətɪ ɪn 'hiːlɪəm]
heat-conduction properties	[hiːt kən'dʌkʃ(ə)n 'prɔpətɪz]
viscosity	[vɪs'kɔsətɪ]
friction	['frɪkʃ(ə)n]
spectroscopy	[spek'trɔskəpɪ]
air fractionation	[ɛə [ˌfrækʃ(ə)'neɪʃ(ə)n]
turbo engine	['tɜːbəʊ 'enʤɪn]
oxygen	['ɔksɪʤən]
electron	[ɪ'lektrɔn]
microwave generator	['maɪkrəweɪv 'ʤen(ə)reɪtə]

3. Read the text about Pyotr L. Kapitsa to learn more about his contribution to physics.

PYOTR L. KAPITSA – PROMINENT RUSSIAN PHYSICIST

Pyotr Leonidovich Kapitsa was born in Kronstadt, near St. Petersburg, on July 9, 1894, in the family of a military engineer and a teacher. Educated at the Petrograd Polytechnic Institute, Kapitsa worked there as a lecturer until 1921. He began his scientific career in A. F. Ioffe's section of the Electromechanics Department.



Here, together with N.N. Semenov, he proposed a method for determining the magnetic moment of an atom interacting with an inhomogeneous magnetic field. Later, this method was used in the famous Stern-Gerlach experiments.

After his first wife and their two small children died of illness during the chaos of the Civil War that followed the revolution of 1917 in Russia, Kapitsa went to England to study at the University of Cambridge. There he worked with Ernest Rutherford and became an assistant director of magnetic research at the Cavendish Laboratory in 1924. He designed an apparatus that achieved a magnetic field of 500 000 gauss, which was not surpassed in strength until 1956. Kapitsa was made a fellow* of Trinity College, Cambridge in 1925 and elected to the Royal Society in 1929, one of only a few foreigners to become a fellow. In 1932 the Royal Society Mond Laboratory was built at Cambridge especially for him. In this laboratory in 1934 he invented and designed a new original device for liquefying helium in large quantities - a prerequisite for the great progress made in low-temperature physics.

In 1934 Kapitsa went on a professional visit to the Soviet Union and was not allowed to return to Cambridge. In 1935 he was made Director of the Institute for Physical Problems of the Soviet Academy of Sciences in Moscow. With the assistance of Ernest Rutherford, the Soviet government bought the equipment for this Institute from the Mond Laboratory. In Moscow Kapitsa continued his research on strong magnetic fields, low temperature physics and cryogenics. In low-temperature physics he discovered superfluidity in helium II in 1937 while investigating its heat-conduction properties. Superfluidity is a state of matter characterized by the complete absence of viscosity. Thus superfluids, placed in a closed loop, can flow endlessly without friction and energy loss. Superfluidity has found an important application in spectroscopy. Thirty years after his discovery of superfluidity, and long after he had moved on to other research topics, Kapitsa was awarded the Nobel Prize in Physics for his low temperature research.

During World War II Kapitsa was involved in applied research on the commercial production and use of oxygen. He developed a highly efficient radial compressed gas turbo engine. Its work is based on air fractionation using only low pressure and it still serves as a world model for large-scale oxygen production plants.

In 1946 Kapitsa refused to work on nuclear weapons development - the Soviet Hydrogen Bomb project, and as a result he was dismissed from his post as the Head of the Institute for Physical Problems.

Study help ***Understanding new words***

While reading, do not use your dictionary each time you come across an unfamiliar word. Read the whole sentence. This will help you guess the meaning from the context.

In 1955 Pyotr Kapitsa returned to Moscow as Director of the Institute. He did not go back to work on low temperatures however, and turned his attention to a totally new range of physical problems. He invented high power microwave generators- planotron and nigotron - and discovered a new kind of continuous high pressure plasma discharge with electron temperatures over a million Kelvin.

In addition to his research achievements, Pyotr Kapitsa became widely known as an outstanding public figure greatly respected for his views. In his paper "The Future of Science" (1962) Kapitsa discussed the tremendous challenge mankind faces in the conquest of outer space. He foresaw the use of nuclear energy to power space vehicles, the use of outer space for the disposal of dangerous radioactive waste products, and the easing of population pressure on earth through colonization of other planets. In another paper Pyotr Kapitsa insisted that science is an international enterprise and that international cooperation and contact are a necessity if science is to progress.

*fellow – *здесь*, член совета колледжа Тринити

4. Answer the questions.

a) When and where did P. Kapitsa start his scientific career?
b) What research problems did he concentrate on during his Cambridge period?
c) What were his major research achievements when he worked in Cambridge?
d) How did P. Kapitsa become Director of the Institute for Physical Problems of the Soviet Academy of Sciences in Moscow? What were his research interests at that time?
e) Why was he dismissed from the post as the Head of the Institute for Physical Problems in 1946?
f) What new range of physical problems did Pyotr Kapitsa turn his attention to when he resumed his work in the Institute?

5. Complete the outline of the text about Pyotr L. Kapitsa.

I. Family, education and early professional background

1) Parents: father - a military engineer, mother - a teacher
2) Education - Petrograd Polytechnical Institute
3) Work in the Electromechanics Department

II. Cambridge period

1) Worked with Ernest Rutherford at Cavendish Laboratory
2) ……
3) …….

III. **Head of the Institute for Physical Problems in Moscow**

1) …….
2) …….
3) …….

IV. **Kapitsa's views and philosophy**

1) … … .
2) … … .

6. **Make use of your outline to sum up what you have learned about Pyotr L. Kapitsa. Present this information to the class.**

Discuss

- What other prominent Russian physicists do you know? Are there any Nobel Prize winners among them?
- What are their most well-known scientific achievements?
- Were their scientific careers successful? Did their discoveries/inventions get immediate recognition from the authorities and public?

Get real

Make up a quiz "Famous Physicists and their Accomplishments". Follow these guidelines:

- ✓ **Think of at least three outstanding physicists who are not mentioned in this unit.**
- ✓ **Search the Internet to find some information about these scientists.**
- ✓ **Make notes of their most significant achievements.**

SPEAKING

Use information from your quiz and give a short talk about some famous physicists. Don't give their names. The rest of the group will have to guess the names of the scientists. The one who guesses the most becomes the winner.

Example:

In 1895 this scientist observed, described and analyzed X-rays that turned out to be high-frequency electromagnetic radiation.

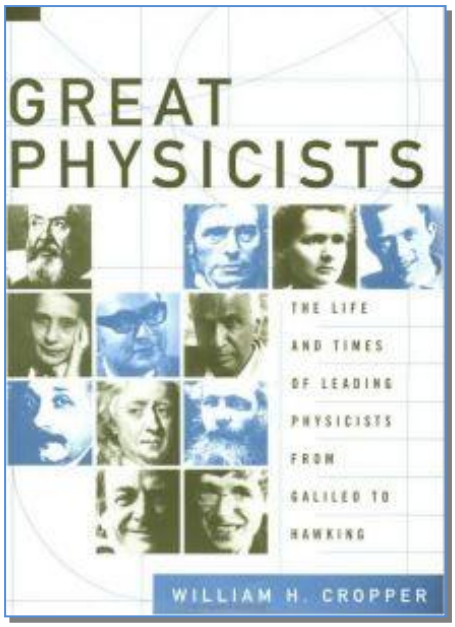
(Wilhelm Roentgen)

WRITING

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.

In the Realm of Science

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

Archimedes	[ˌɑ:kɪ'mi:di:z]	Isaac Newton	['aɪzək 'nju:t(ə)n]
Socrates	['sɒkrəti:z]	James Maxwell	[ʤeɪmz 'mækswel]
Plato	['pleɪtəu]	Michael Faraday	['maɪk(ə)l 'farədeɪ]
Aristotle	['arɪstɒt(ə)l]	Wilhelm Roentgen	[ˈvɪlhelm 'rɔntgən]
Ptolemy	['tɒlɪmɪ]	Ernest Rutherford	[' ɜ:nɪst 'rʌðəfəd]
Nicolaus Copernicus	['nɪk(ə)ləs kə'pɜ:nɪkəs]	Albert Einstein	['ælbət 'ʌɪnstʌɪn]
Johannes Kepler	[ʤəu'hæni:s 'keplə]	Max Plank	[mæks pla:ŋk]
Galileo Galilei	[ˌgælɪ 'leɪəʊ 'gælɪleɪ]	Stephen Hawking	[' sti:vən 'ho:kɪŋ]

2. Learn how to read some of the letters of the Greek alphabet.

Capital and small	Name	English equivalent	Russian
Α α	a [ˈælfə]	a	альфа
Β β	beta [ˈbi:tə]/[ˈbeɪtə]	b	бета
Γ γ	gamma [ˈgæmə]	g	гамма
Δ δ	delta [ˈdeltə]	d	дельта
Λ λ	lambda [ˈlæmbdə]	l	лямбда
Μ μ	mu [ˈmju]	m	ми/мю
Ξ ξ	xi [ˈksaɪ]	n	кси
Π π	pi [ˈpaɪ]	p	пи
Σ σ	sigma [ˈsɪgmə]	s	сигма
Ώ ω	omega [ˈoʊmɪgə]	o	омега

Progress Monitoring

In this unit you have worked on the vocabulary on the topic: "History of Physics".

Tick (V) the points you are confident about and cross (X) the ones you need to revise.

1. to accept myths on faith
2. to design practical devices
3. to measure the density of solid bodies
4. to have a significant/major impact on sth
5. to conduct experimentation
6. to be of great importance for sth
7. to introduce the heliocentric system
8. to come up with a remarkable result
9. forefathers/founding fathers of physics
10. to validate theory with experimentation
11. to become a masterpiece of scientific insight
12. to propose a method for determining sth
13. to surpass in strength
14. to become widely known
15. to lead to revolutionary changes
16. to be involved in applied research on sth
17. to face the tremendous challenge
18. to turn one's attention to sth
19. disposal of dangerous waste
20. to lay the foundation of sth

Progress Test

1. Cross out the odd word. Explain your choices.

a) effort, attempt, effect, try
b) to study, to inform, to investigate, to research
c) vision, advent, arrival, coming
d) to inspire, to encourage, to support, to determine
e) accurately, correctly, actually, exactly
f) approach, discovery, innovation, breakthrough

2. Give English equivalents to these Russian word combinations.

a) подтвердить теорию экпериментально
b) основатель естествознания
c) бросить вызов физике Ньютона
d) теория электромагнитного поля Максвелла
e) специальная теория относительности
f) квантовая теория
g) заложить фундамент чего-либо

3. Write the word and the Russian equivalent next to each transcription.

e.g. ['prɔpətɪ] – property – свойство

a) [ˌrelə'tɪvətɪ]
b) ['den(t)sɪtɪ]
c) [ˌsu:pəflu:'ɪdɪtɪ]
d) [əkˌselə'reɪʃ(ə)n]
e) [vɪs'kɔsətɪ]
f) ['frɪkʃən]
g) ['endʒɪn]

4. Underline the correct type of the Participle in the sentences below. Translate the sentences into Russian.

a) Kepler's breakthrough overturned a millennium of dogma *basing/based* on Ptolemy's idea of 'perfect' circular orbits for the 'perfect' heavenly bodies.
b) In 1821 Michael Faraday discovered that a wire *carried/carrying* a current could be made to rotate in a magnetic field.
c) Thomas Edison found that light *produced/producing* by carbon fiber lasted a long time without burning up.
d) Two centuries of experimental discoveries in electricity and magnetism *expressed/expressing* in Maxwell's four famous equations made it possible to successfully unify two phenomena into one – electromagnetism.
e) Einstein's development of the special and general theories of relativity *described/describing* space and time in a new way changed physics forever.
f) According to the archives, the top three physicists *admired/admiring* most by Einstein, were all British: Newton, Faraday and Maxwell.