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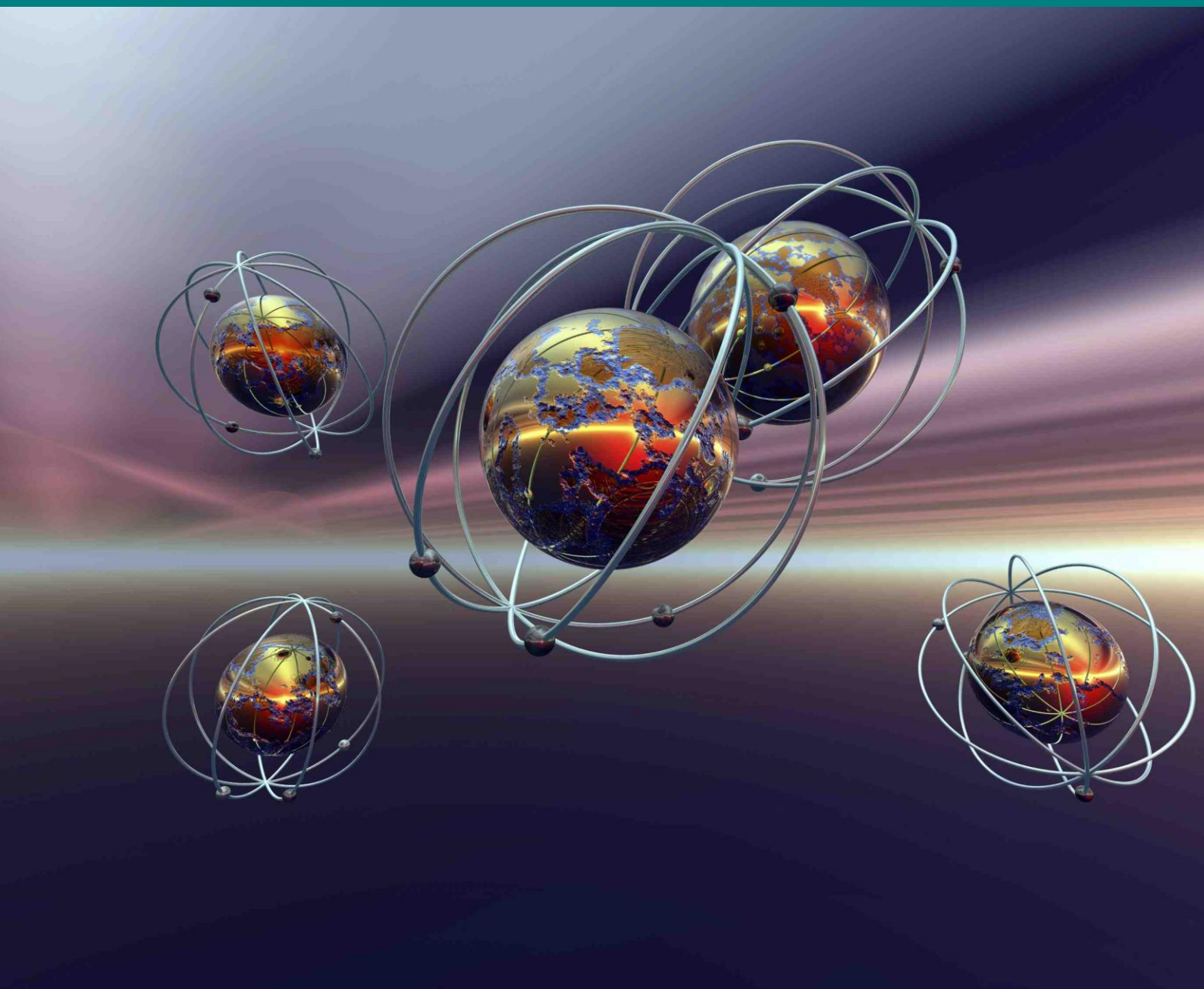
LEARN THE ENGLISH OF PHYSICS



Федеральное государственное автономное образовательное учреждение высшего профессионального образования «ЮЖНЫЙ ФЕДЕРАЛЬНЫЙ УНИВЕРСИТЕТ»

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Английский язык для студентов физических специальностей

Learn the English of Physics

Учебник английского языка

для студентов 1-2 курсов физических специальностей университетов

Рекомендовано Научно-методическим советом по иностранным языкам Министерства образования и науки РФ в качестве учебника для студентов высших учебных заведений, обучающихся по естественнонаучным специальностям

Ростов-на-Дону

Издательство Южного федерального университета

2014

Английский язык для студентов физических специальностей: Учебник/ О.И. Сафроненко, Е.И. Грушко, К.С. Петросян

На учебник получен гриф научно - методического совета по иностранным языкам (Протокол №4 от 7 ноября 2012 г.): ***«Рекомендовано Научно - методическим советом по иностранным языкам Министерства образования и науки РФ в качестве учебника для студентов высших учебных заведений, обучающихся по естественнонаучным специальностям»***

Аннотация

Целью учебника “Learn the English of Physics” является формирование иноязычной коммуникативной компетенции в сфере учебной и будущей профессиональной деятельности студентов-физиков. Достижение поставленной цели осуществляется с использованием оптимального сочетания когнитивных, коммуникативных и рефлексивных методов в обучении английскому языку, а также личностно-ориентированного подхода и современных интернет-технологий.

Данный учебник включает 10 разделов, в каждом из которых рассматривается одна из областей физики, представляющая основные направления профессиональной подготовки студентов физических специальностей.

Учебник “Learn the English of Physics” предназначен для студентов 1-2 курсов физических специальностей университетов со средним уровнем (B1-B2) владения английским языком.

CONTENTS

Предисловие

Учебник “Learn the English of Physics” предназначен для студентов 1-2 курсов физических специальностей университетов. Его целью является формирование иноязычной коммуникативной компетенции в сфере учебной и будущей профессиональной деятельности студентов-физиков, что предполагает успешное овладение английским языком как средством их дальнейшего профессионального развития.

Предлагаемый учебник ориентирован на создание условий для приобретения студентами опыта использования языковых знаний и умений в различных ситуациях академического и профессионального общения; развития творческого подхода к решению учебных и профессиональных задач; формирования умений самостоятельной работы; активного использования современных информационных технологий; коллективной познавательной деятельности; самоконтроля и оценки усвоения формируемых навыков и умений.

Данный учебник включает 10 разделов, в каждом из которых рассматривается одна из областей физики, представляющая основные направления профессиональной подготовки специалистов-физиков.

Каждый раздел содержит материалы для развития навыков всех видов речевой деятельности (говорения, аудирования, чтения и письма), навыков устной и письменной коммуникации, грамматические упражнения, задания для самоконтроля, а также задания для реализации творческого потенциала студентов (составление логико-смысловых карт, проведение презентаций, выполнение проектных работ и др.).

Также, в каждом разделе вводятся и закрепляются терминологические единицы, характерные для подъязыка определенной специальности, развиваются и совершенствуются коммуникативные навыки и учебные стратегии. В конце раздела предлагается тест рубежного контроля, включающий задания на проверку, осмысление и закрепление изученного материала. К учебнику также разработаны материалы для преподавателя, которые включают текстовую основу для прослушивания (scripts) и ключи к наиболее трудным заданиям.

Типология используемых в учебнике заданий разнообразна и представлена следующими рубриками:

Lead in – включает задания, имеющие своей целью выяснить фоновые знания, мнения, суждения студентов по обсуждаемой в каждом разделе тематике.

Reading – предлагает задания на развитие навыков в различных видах чтения, извлечение информации, понимание структуры, организации, содержания текста.

Listening – представляет собой аудиозаписи монологов и интервью академической и профессиональной направленности, сопровождающиеся заданиями, направленными на

извлечение конкретной информации, развитие навыков конспектирования, переработки и передачи информации на английском языке.

Focus on language - акцентирует внимание на определенных грамматических аспектах, ключевых словах и словосочетаниях изученных в рамках раздела, включает задания на расширение словарного запаса студентов.

Discuss – предлагает вопросы, позволяющие выявить отношение к прочитанному материалу и соотнести его с собственными знаниями, интересами студентов, имеющимся у них опытом.

Get Real – предполагает использование умений поиска информации на интернет сайтах и в научно-популярных публикациях в условиях, максимально приближенных к ситуациям реальной учебной деятельности.

Writing – предлагает различные задания, направленные на развитие умения фиксировать информацию на английском языке с использованием различных форм записи (составление плана, коротких заметок, конспектирования, аннотирования, реферирования, и т.д.).

Speaking - содержит задания, направленные на формирование умений диалогического, а также неподготовленного и подготовленного монологического высказывания.

Summarizing – имеет своей целью формирование навыков аннотирования научно-популярных русскоязычных текстов на английском языке.

In the Realm of Science – включает дополнительный справочный материал, отражающий специфику естественнонаучных специальностей (общепринятые сокращения, символы и т.д.).

В данный учебник включены также специальные рубрики:

Study help содержит полезные советы по использованию стратегий изучения английского языка, а также рациональные приемы работы над лексическим и грамматическим материалом и т.д.

Progress Monitoring – представляет задания, стимулирующие рефлексивную самооценку процесса изучения английского языка, позволяющие студентам последовательно и адекватно отслеживать свои учебные достижения, успешность продвижения в овладении иностранным языком.

Progress Test – представляет собой тест рубежного контроля.

Учебник разработан с использованием аутентичных материалов, основными источниками которых являются британские и американские академические и научно-популярные издания, Интернет, проспекты ведущих университетов англоязычных стран, энциклопедии, словари. При подборе учебных материалов учитывались такие характеристики, как новизна информации, ее познавательность, соответствие учебным и профессиональным потребностям студентов.

UNIT 1

WHY STUDY PHYSICS?

"The list of problems solved is long; the list of future possibilities is endless. So there is some truth in the statement that physics has to do with everything."

Department of Physics - Worcester Polytechnic Institute

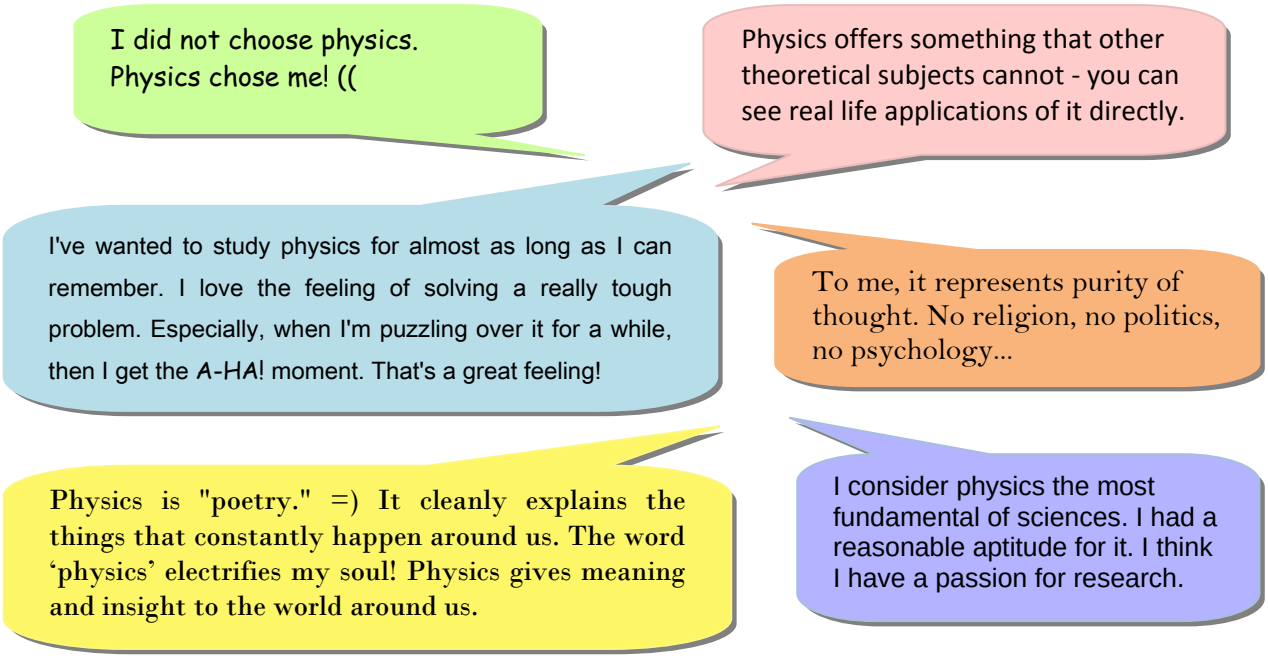
Learning Objectives

In this unit you will:

- ✓ learn the terms connected with fields of physics
- ✓ revisit noun phrases
- ✓ revisit frequently used verb tenses
- ✓ talk about studying physics at university
- ✓ write a Student Profile
- ✓ study the organizational pattern of a text
- ✓ practise summarizing skills

LEAD IN

1. **Work in small groups. Read the answers to the question "Why did you choose physics?" posted on one of the *Physics forums* for students majoring in physics.**



How would ***you*** answer this question? Why did **you** choose to do a physics course at university?

2. **Sum up your ideas and share them with the rest of the class.**

READING

1. **Read the text and make a list of the reasons for doing a course in physics.**

WHY STUDY PHYSICS?

Physics is the most basic and fundamental of all the sciences. Studying physics means trying to understand how things work, in every detail and at the deepest level. This includes everything from elementary particles, nuclei, atoms, molecules, macromolecules, living cells, solids, liquids, gases, plasmas, the atmosphere to living organisms, the human brain, complex systems, supercomputers, planets, stars, galaxies and the universe itself. Physics has the reputation of being a difficult subject to master but there are a number of reasons why it is a good idea to do a course in physics.

For one thing, most modern technology involves physics. Any technology involving electricity, magnetism, force, pressure, heat, light, energy, sound, optics, etc., comes from physics. Indeed, physics lies in the basis for all types of analytical and measuring systems. Even though the basic knowledge required for products like fertilizers, drugs, plastics, and chemicals comes from chemistry and biology, these items have to

eventually be manufactured, and manufacturing is dominated by physics-based technology. So, it is evident that an understanding of physics leads to a better understanding of almost any other science.

The discipline of physics also teaches skills that are transferable to a great number of professions. These skills include: problem solving, mathematical modeling, designing and performing experiments, interpretation and analysis of experimental data as well as project planning, report writing and presentation.

Moreover, studying physics opens doors to a wide variety of careers. Physicists are engaged in all sorts of interesting jobs because of their broad training and adaptability. As a working physicist you may find yourself trying to predict the stock market on Wall Street, testing satellites for space missions, developing new materials for industry, developing new electronic devices and components, doing medical physics in a hospital, teaching the next generation of physicists at high school, trying to predict the next major earthquakes around the globe, developing flight simulation software, optimizing industrial manufacturing or transformation processes, developing a new measurement instrument, performing materials testing and characterization for special applications, launching a new software company or product, performing urban planning and optimization, etc.

It is interesting to know

Many commonly used expressions in everyday language come from physics, including *quantum leap, free fall, light years, black holes, resonance and being on the same wave length, etc.*

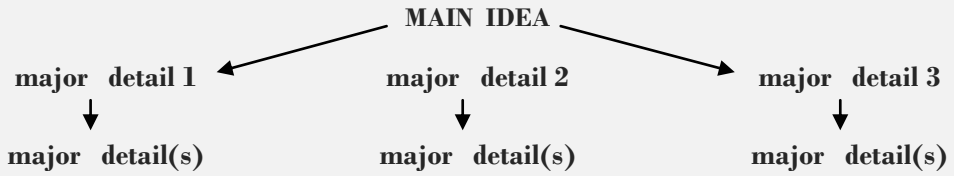
Apart from that, knowledge of physics is helpful for understanding the arts. Physics is the science of sound and is needed to understand how musical instruments work. It is also the science of light and is a key to understanding visual artwork including paintings, photograph as well as stage lighting and filmmaking.

All in all, physics is central to the economy of a great number of countries around the globe. Whether through the application of novel research and technologies, or through the skills and abilities of physics-trained workers, physics drives businesses and innovation.

2. **Read the text again and highlight the signal words that introduce supporting details. What is their function? Make use of the *Study help* box.**

Study help ***Getting ready to read***

Any reading selection has a particular organizational pattern. It has a topic - the name, theme, or general subject, e.g., a title or heading. The topic helps to find out the main idea of the passage which can be found in the beginning, middle, or end of the passage. There are also supporting details. These are the sentences in a passage that explain the different points of the main idea. There are two types of supporting details: major and minor. Major details directly develop the main idea; minor details develop major details. Supporting details provide the reader with additional information, e.g. data, statistics, steps in a process and examples. Supporting details are usually introduced by signal words, e.g., *also, however, moreover* (major details); *for example, that is* (minor details), etc.



3. **Complete the chart to sum up the information from the text. Use the chart as an outline.**

Topic	
Main idea	
Major detail(s)	
Minor detail(s)	

4. **Match the words in *A* with the words in *B* to make phrases used in the text.**

A	B
1) to do	a) science
2) to perform	b) a course in physics
3) project	c) writing
4) to master	d) problems
5) report	e) skills
6) fundamental	f) planning
7) to develop	g) a subject
8) to solve	h) experiments
9) transferable	i) a device or instrument

Discuss

- Which reasons described in the text motivated you to choose the Physics faculty? Did you have any other reasons?
- What commonly used expressions in everyday language that come from physics do you know? What particular fields of physics do they come from?
- Are career opportunities for physicists good in Russia? What are they?

Focus on language

Study help

It is important that you are able to distinguish between the **terms** (*e.g. electron*) and **general science words** (*e.g. experiment*). Make sure you note down such words in your notebook throughout your course. Keep it up to date. ✍

1. **Practice the pronunciation of these words. Which of them are terms and which are general science words? Add some more words from the text you have read to each group.**

nucleus/nuclei	['nju:klɪəs] ['nju:klɪaɪ]	electricity	[ɪˌlek'trɪsətɪ]
concept	['kɔnsept]	system	['sɪstəm]

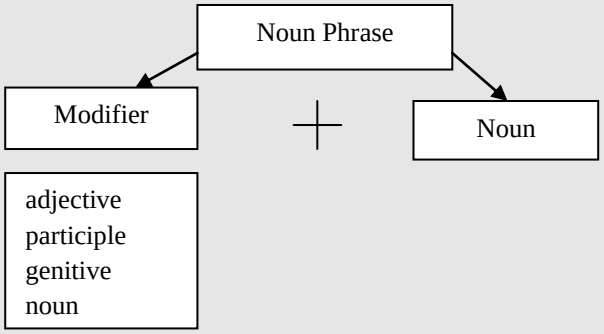
measurement	['meʒəmənt]	quantum	['kwɔntəm]
application	[ˌæplɪ 'keɪʃ(ə)n]	magnetism	['mægnətɪz(ə)m]
instrument	['ɪn(t)strəmənt]	component	[kəm'pəʊnənt]
molecule/molecular	['mɔlɪkju:l]/[mə 'lekjulə]	fundamental	[ˌfʌndə'ment(ə)l]

2. **Read the sentence and translate the phrases in bold into Russian.**

*As a working physicist you may find yourself testing satellites for **space missions**, developing new **electronic devices** and **components**, doing **medical physics** in a hospital, teaching the next generation of physicists at **high school**, etc…*

Noun Phrases

Study the diagram describing the components of noun phrases.



innovative technology – technology that is new and different *(adjective)*
transmitting antenna – antenna that transmits signals *(participle)*
professor's lectures – lectures given by the professor *('genitive)*
star formation – the formation of new stars *(noun)*

3. **Look back in the text. Write out the noun phrases that follow the models in the box. There are sometimes more than two components in the noun phrase. Translate the noun phrases into Russian.**

Example: adjective+noun - modern technology – современная технология
participle+noun - measuring systems – измерительные системы

SPEAKING

1. **Work in teams. For each field of physics (1-10) brainstorm two or three terms that go with it. Compare as a class.**

Example: condensed matter physics – *solid, liquid, gas, etc.*

2. **Match the field of physics with the area(s) of its application.**
3. **Make use of the models in the *Study help* box to share your ideas about these branches of physics and their applications.**
   Check as a class.

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

FIELDS OF PHYSICS	AREAS OF APPLICATION
	a) to create large capacity disks
	b) to develop medical imaging instrumentation
1) OPTICS	c) to make new materials
2) BIOPHYSICS	d) to set up satellite communication
3) RADIOPHYSICS	e) to build telescopes
4) NUCLEAR PHYSICS	f) to operate a nuclear reactor
5) NANOPHYSICS	g) to produce computer chips
6) CONDENSED MATTER PHYSICS	h) to design and create smart machines
7) ASTROPHYSICS	i) to modify microorganisms for biofuel and bioelectricity
8) PARTICLE PHYSICS	j) to develop atomic size machines
9) ACOUSTICS	k) to determine the age of an ancient object or a person
10) MECHANICS	l) to create better concert halls
	m) to develop lasers
	n) to understand the birth and evolution of the Universe
	o) to develop intercontinental broadband data channels
	p) to examine the level of safety of the car and its occupants

Study help ***Avoiding repetition or paraphrasing***

We can use various speech patterns when we need to speak about similar things but do not want to be repetitive.

- Without condensed matter physics ***production*** of computer chips would be impossible.
  (noun)
- Condensed matter physics makes it possible/enables us ***to produce*** computer chips.
  (verb)
- Condensed matter physics deals with/has to do with ***computer chip production.***
  (noun phrase)
- The knowledge of condensed matter physics is necessary ***for producing*** computer chips.
  (gerund)

LISTENING

1. Before you listen, match the types of university courses in *A* with their definitions in *B*.

A	B
1) **core**	a) a course made up of different subject blocks which deal with particular areas of interest and may be delivered using a range of lectures, seminars and/or workshops
2) **elective**	b) a compulsory or required course which is essential for an academic degree
3) **modular**	c) a course chosen within the specialist subjects or in an associated field that provides students with multi-disciplinary approach as well as professional qualifications
4) **optional**	d) a course chosen by students from completely different subject areas in order to broaden their academic interests

2. Match the subject areas with the topics.

Subject areas	Topics
1) Electromagnetism	a) The Schrödinger equation
2) Optics	b) Crystalline lattice
3) Atomic Physics	c) Delphi, C++
4) Quantum Mechanics	d) Interference & diffraction
5) Solid State Physics	e) Star formation
6) Mathematics	f) Interpolation
7) Computer Programming	g) Radiation
8) Numerical Methods	h) Differentiation and integration
9) Astrophysics	i) Maxwell's equations

3. Listen to Daniel who is describing his university course in physics. Answer these questions.

a) Why is it convenient for students to have a common first year in all of the ***"Physics with…"*** programmes?

b) Which of the subjects listed in Task 2 does Daniel mention as his 'Core' physics modules?

c) What 'Optional' modules does he speak about?

d) What skills do students develop throughout their degree?

e) What is a Professional Training Year? How do students benefit from it?

f) Why are electives in Modern Languages popular with the physics students?

g) Why did Daniel get interested in the single subject Physics degree course?

h) What is the title of his final year research project?

i) What is Daniel planning to do after he gets the BSc degree?

Discuss

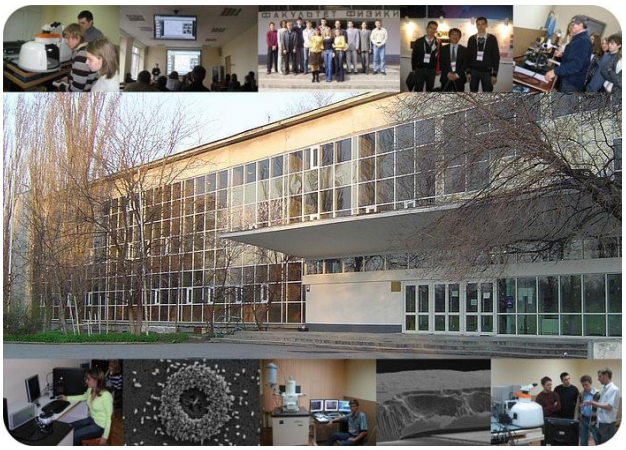
- Name the course(s) in physics you are doing now at university. Are these courses theoretical or practical?
- Which course do you enjoy most? Why?
- Which new courses are you going to take next semester? What topics do they cover?
- Would you be interested in doing a professional training year (what subject area and what country)?

Get real

1. **Go online. Study the web site or the Prospectus of the Faculty of Physics at your university and find information about your own physics degree programme.**
   Write a description of the physics course you are doing. Be sure to include:

   - ✓ aims of the course
   - ✓ course outline
   - ✓ length of study & qualification awarded
   - ✓ teaching & assessment methods
   - ✓ learning facilities

2. **Present the description of your physics course to the class.**

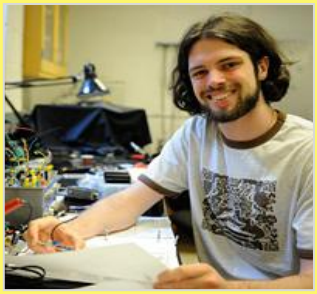


READING

Read the student profile and take notes under the headings:

- ❖ reasons to study physics
- ❖ reasons to choose Strathclyde University
- ❖ length of study and degrees
- ❖ achievements
- ❖ leisure time activities

Study help
A **profile** is a short article about someone, a description of a person that contains all the details that someone needs to know this person better.



Student Profile

Michael Smith

After leaving school in 1998 with several standard grades, I went to college and completed an NVQ (National Vocational Qualification)* in travel and tourism and for the next four years I worked as a business travel agent in Edinburgh. I always regretted not following my original dream of going to university, so I went to night school to gain the relevant qualifications required for university entry. From the very beginning I wanted to study physics at Strathclyde University. Physics was my favourite subject at school and Strathclyde offers the most interesting and applicable courses. In fact, it seemed the ideal choice of university for me. The research facilities at Strathclyde are excellent, there are always computers available on campus 24 hours a day and the libraries are easy to work in.

There were many aspects of physics which initially interested me. I loved mathematics and finding out how and why things worked. This interest grew and developed during my time at Strathclyde. So, over the next four years I learned various branches of physics through completion of theoretical and experimental classes and eventually earned a BSc Honours degree*. I enjoyed my undergraduate degree so much that when I finished I began a PhD with the Bimolecular and Chemical Physics group at the university.

One of my other primary interests is teaching physics. Over the years I have come to believe that guiding others through their physics journey is very rewarding and it helps me to improve my teaching skills. I hope I have found a job that allows me to achieve a balance of research and teaching.

So how do I spend my free time? I enjoy working with my Mac (yes, a Macintosh!). Also, I've been trying to improve my programming skills. I took a C++ course here at Strathclyde University where we had to build a library as a final project. My circuit simulator is on-line, with a fair amount of documentation. It's nothing spectacular as it was my first "real" C++ project, but it was good enough to give me a taste of the language.

My another 'love' is music. At the moment I'm learning to play the guitar. (It's not easy but I'm working really hard). I don't mind practicing every day, really, as I've always wanted to play the guitar and to be the centre of attention at parties!

Besides, when possible I take part in department social events and like to help out with open evenings and department tours. I am also involved with the Physics Society.

I am sure that the best years of your life are those that you spend studying at university!

*NVQ - государственный сертификат о профессиональном соответствии
*BSc Honours degree - степень бакалавра наук с отличием

Focus on language

1. **Look back in the profile. What verb tenses are used? Why does the author use these particular tenses?**
2. **Join the beginnings with the ends to make rules about the usage of these *Present & Past Tenses.***

Present Simple		✓ to talk about an activity or situation that began and ended at a particular time in the past
Present Progressive	is used	✓ to speak about activities that began in the past, continue to the present and are still in the process
Past Simple		✓ for the event that started in the past and has been recently completed
Present Perfect		✓ to speak about permanent situations and routines
Present Perfect Progressive		✓ to describe activities that are happening at or around the time of speaking

3. Complete the sentences with the correct tenses.

a) At the moment Graham also *(to do)* a course in scientific journalism and he *(to seem)* to enjoy it greatly.
b) One of the things I *(to like)* about the atmosphere at college *(to be)* that students *(to study)* across the disciplines.
c) Since arriving in Manchester to study physics, Helen *(to not look back)*. She *(to be)* on the mechanical subgroup and *(to do)* theoretical modeling.
d) I *(to do)* a course in programming languages for my science project for a month, so now I *(to get)* more comfortable with basic mathematical concepts.
e) Bryan *(to receive)* his doctorate from The University of Sydney in 2008. He then *(to take up)* a prestigious Hubble Fellowship at the Massachusetts Institute of Technology (MIT) where he *(to become)* involved in X-ray studies of the Milky Way.
f) My friend *(to decide)* to take the science route and *(to plan)* to begin the Ph.D. track in physics at Boston University.
g) Through my work on the GRB* satellite, I *(to learn)* a few things about signal detection in relatively noisy environments. In fact, I *(to make observations)* for a year now.
h) Many of the university lecturers *(to be involved)* in front-line research and they *(to share)* the details of this work with their students.
i) Look at them! Everybody *(to be pleasantly surprised)* with the results. They never *(to do)* anything like this before, but it (to work)!
j) While doing my BSc course I (*to spend*) a research year abroad working in one of the Nuclear Physics laboratories. It *(to be)* a fantastic experience on both professional and personal levels.

* GRB (gamma-ray bursts) - гамма-всплеск

WRITING

Use the *Michael Smith's Profile* as a model to write your personal Physics Student Profile in 150-200 words. Make use of the guidelines.

Paragraph 1

Your education background and reasons for choosing to study physics at university

Paragraph 2

The length of studying at the physics faculty
The subjects you are studying this semester
Your study experience and achievements
Compulsory and optional courses you are going to take in your third year at university

Paragraph 3

Your favourite leisure activities, how they contribute to your student life

SPEAKING

Prepare a short talk based on your profile to give in class. Be ready to answer the questions about your studies at the physics faculty and your student life.

Summarizing

1. **Read the text «Что значит изучать физику?» and highlight the Russian equivalents to the English word combinations (1-11).**

1) to learn formulae and laws
2) to attend lectures and seminars
3) to gain practical knowledge of experimental methods in physics
4) to do laboratory work
5) to take accurate measurements
6) to evaluate the reliability of the results
7) to gain professional skills
8) a theorist, an experimentalist
9) physics graduates
10) to formulate and solve complicated problems
11) to make someone a real expert in various spheres of life

Add new vocabulary to your vocabulary notebook. ✍

Что значит изучать физику?

Физика – фундаментальная наука. При ее изучении важно не только выучить какие-либо формулы и законы, необходимо научиться думать, размышлять «физически». Например, посещая лекции и семинарские занятия, студенты учатся решать задачи, а лабораторные работы позволяют студентам овладеть практическим познанием экспериментальных методов физики. Выполняя лабораторные работы, студентам необходимо не только точно производить измерения, но и уметь из полученной информации извлечь полезные результаты, оценить степень их достоверности. Именно в ходе такой работы студент приобретает профессиональные навыки, необходимые не только экспериментатору, но и будущему теоретику.

В последние годы некоторые выпускники физических факультетов находят себя в различных сферах человеческой деятельности, не связанных с физикой. Именно «физическая» подготовка, умение ставить и решать сложнейшие задачи, навык анализировать и оценивать делают их настоящими специалистами в бизнесе, банковском деле, экономике и других областях.

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

Phrases for summarizing

The article discusses/considers… **The article informs/presents information about…**

It is reported/said/stated that… **It is pointed out/claimed that…**

Actually; In fact; In particular; For example; Also; Moreover; However; All in all; Finally, etc.

In the Realm of Science

1. **Words of the Latin origin are widely used in scientific papers and other publications. Here are some of the commonly used Latin words.**

cf. (confer)	compare
NB (nota bene)	take special note
e.g. (exempli gratia)	for example/for instance
etc. (et cetera)	and so on
et al. (et alii)	and others/and co-workers
i.e (id est)	that is, in other words
in vitro	taking place outside a living body
in vivo	taking place in a living body
per cent. (per centum)	one part in every hundred
vice versa	in reverse order from that stated
vs. (versus)	against

2. **Remember how to pronounce the names of some fields of physics.**

acoustics	[ə'kuːstɪks]	nanophysics	['nænə'fɪzɪks]
biophysics	['baɪəʊ'fɪzɪks]	mechanics	[mɪ'kænɪks]
photonics	[fəʊ'tɒnɪks]	nuclear physics	['njuːklɪə 'fɪzɪks]
astrophysics	[ˌæstrə(ʊ)'fɪzɪks]	particle physics	['paːtɪkl 'fɪzɪks]
geophysics	[ˌʤiːəʊ'fɪzɪks]	radiophysics	['reɪdɪəu'fɪzɪks]
thermodynamics	[ˌθɜːmədaɪ'næmɪks]	electromagnetism	[ɪˌlektrəʊ'mægnɪˌtɪzəm]
quantum electronics	['kwɔntəm ˌɪlek'trɔnɪks]	condensed matter physics	[kən'den(t)st 'mætə 'fɪzɪks]

Progress Monitoring

In this unit you have worked on the vocabulary on the topic: "Studying Physics at University".
Tick (*V*) the points you are confident about and cross (*X*) the ones you need to revise.

1. to do a course in physics
2. a compulsory (core)/optional/elective course
3. a single subject degree course/a modular degree structure
4. to choose speciality
5. lectures/laboratory work/tutorials/workshops
6. the guidance and support of a departmental academic supervisor
7. problem solving/project planning/report writing/ presentation skills
8. to undertake professional placement
9. to gain 'real life' hands-on experience
10. excellent research facilities
11. to design and perform experiments
12. to take part in department social events
13. state-of-the-art optional courses
14. to do a final year research project
15. interpretation and analysis of experimental data
16. to develop new measurement instruments/electronic devices/components
17. to gain relevant knowledge/qualification/ professional skills
18. to open doors to a wide variety of careers
19. broad training and adaptability
20. to make someone a real expert in sth

Progress Test

1. **Cross out the odd word. Explain your choices.**
   a) radiation, magnetism, mechanics, sound
   b) solids, liquids, gases, pressure
   c) technique, spectrometer, microscope, satellite
   d) to develop, to manufacture, to test, to design
   e) concept, idea, knowledge, theory
   f) acoustics, quantum optics, meteorology, star formation

2. **Give English equivalents to these Russian word combinations.**
   a) учить формулы и законы
   b) ставить/формулировать и решать сложные задачи
   c) экспериментальные методы физики
   d) посещать лекции и семинары
   e) выпускники физических факультетов
   f) приобретать профессиональные навыки
   g) делать кого-то настоящим специалистом

3. **Write the word and the Russian equivalent next to each transcription.**
   e.g. [ɪ'kweɪʒn] - equation - уравнение
   a) [ɪk'spɪərɪəns]
   b) [rɪ'sɜːʧ]
   c) [ˌʌndə'grædjuət]
   d) [fə'sɪlətɪz]
   e) ['fɪzɪsɪst]
   f) [tek'niːk]
   g) [ˌfʌndə'ment(ə)l]

4. **Complete the sentences with the verbs in the correct tense forms.**
   a) Since her childhood Sandra McLean *(to be interested)* in stars, planets and galaxies.
   b) According to the National Aeronautics and Space Administration (NASA) website, gamma ray bursts *(to be)* the most powerful explosions the universe *(to see)* since the Big Bang.
   c) I *(to love)* being a student at Manchester University. I *(to choose)* to come here first because of the exemplary physics degree programme which covers all the topics that *(always to interest)* me, including modern physics such as relativity and quantum mechanics.
   d) He (to enjoy) studying here because the facilities *(to be)* excellent and the university *(to have)* links with other major research centres such as CERN so the teaching *(to be)* always up to date.
   e) As far as I know, Chris *(to work)* at Los Alamos National Laboratory for three years now.
   f) I (*just; to start*) a Master's degree course in astrophysics.

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."

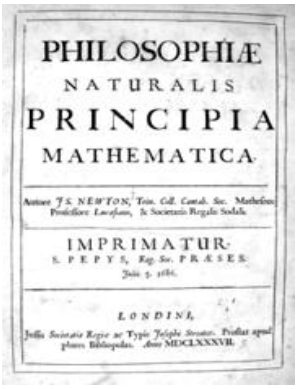
  Was the poet right?
- Which phenomena and laws of nature did Isaac Newton study and explain?
- What is the name of the book in which Newton formulated his famous laws?

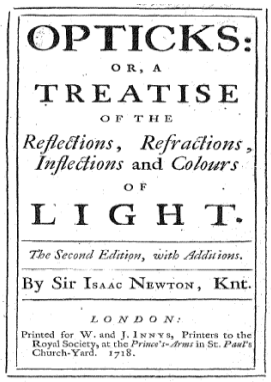
2. **Work in small groups. Brainstorm the most outstanding accomplishments made by Isaac Newton in science and report your ideas to the rest of the class.**

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

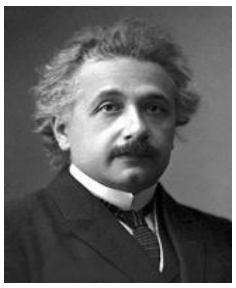
Add new vocabulary to your vocabulary notebook. ✍

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.**

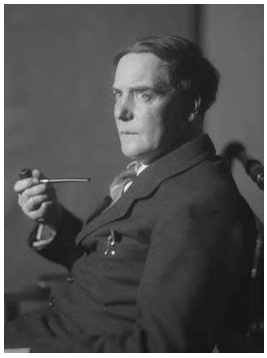
magnetic moment of an atom	[mæg'netɪk 'məumənt əv ən 'ætəm]
inhomogeneous magnetic field	[ˌɪnhɒmə(ʊ)'dʒi:nɪəs mæg'netɪk fi:ld]
to liquefy helium	['lɪkwɪfaɪ 'hi:lɪəm]

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.

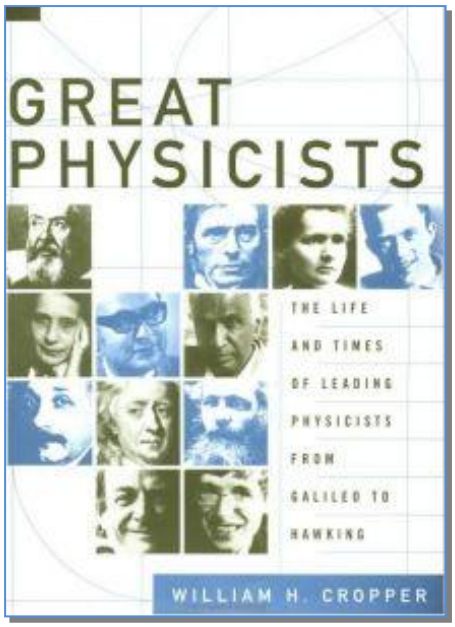
(Wilhelm Roentgen)

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.

UNIT 3

IN THE LAB

"Look deep into nature, and then you will understand everything better"

Albert Einstein

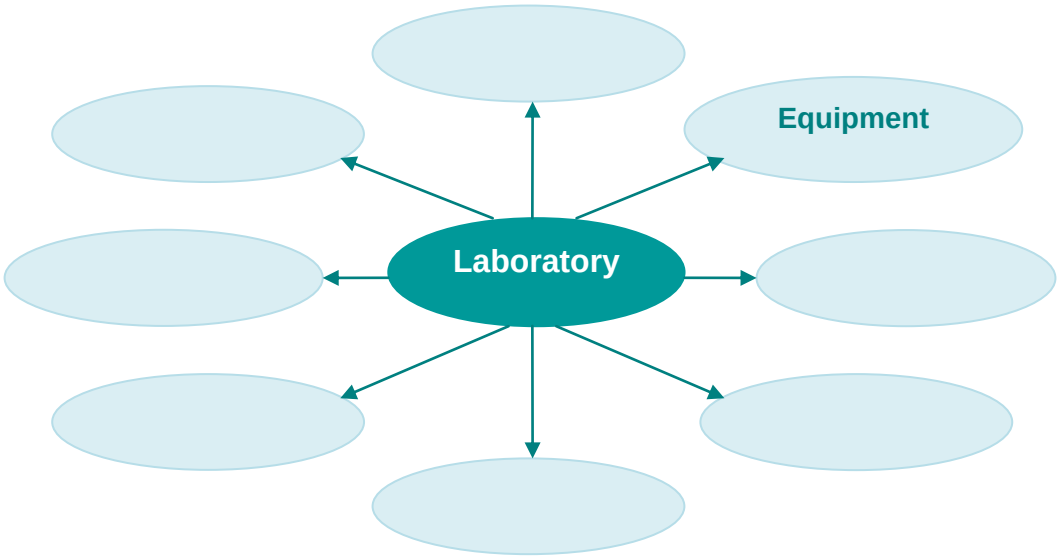
Learning Objectives

In this unit you will:

- ✓ learn the names of instruments and devices used in physics
- ✓ distinguish international words from 'false friends' words
- ✓ revisit different functions of modal verbs
- ✓ talk about the importance of laboratory classes
- ✓ write a brief description of a tool/device
- ✓ study the structure of a lab report
- ✓ practise summarizing skills

LEAD IN

1. **Work in small groups. Brainstorm 7-10 words to complete the mind map for the word *'laboratory'*. Discuss as a class.**



2. **Give a definition to the word *'laboratory'*. Compare the definitions as a class.**
3. **Answer the questions.**

- Are there many laboratories at your faculty? What are they?
- Do you often work in the lab?
- Which courses in physics require doing lab work?
- What kind of laboratory equipment and tools do you use?
- What do you like/dislike most about your laboratory classes?
- What do you find difficult about them? Why?

READING

1. **Give the Russian equivalents to these words and phrases. Use a dictionary if necessary.**

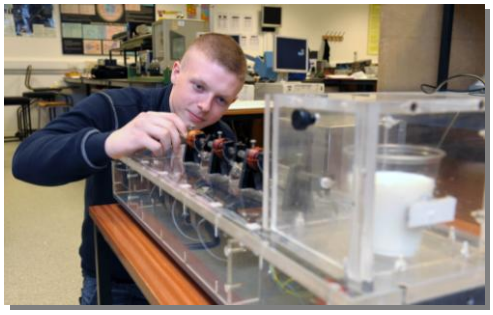
- to get a benefit from sth
- a scientific technique
- intellectual exploration
- a laboratory manual
- derivations and equations
- to suggest an approach to sth
- to be fruitful
- the thrill of discovering sth
- to draw conclusions
- to correlate sth with sth
- to prospect for minerals
- to substitute values into equation
- innumerable examples
- a command of one's native language

2. **Read the text about the importance of laboratory work in physics.**

THE LABORATORY

The laboratory work in physics can be an exciting or boring part of the course depending upon your attitude toward it. If you regard it as an obstacle to your getting through the course, probably you will get very little benefit from it. On the other hand, if you regard it as an opportunity to learn more, then it is almost certain you will find the time you spend in the lab both profitable and interesting.

There are several ways in which you may expect to benefit from the laboratory work. It helps you to understand and remember the physics you have studied by practicing the application of physical laws and logic to real cases, which helps you to think clearly and gives you some skill in the use of scientific instruments and techniques.



It is true that you are not likely to be the discoverer of anything new in physics during your first-year course, as most (but not all) of the material in first-year physics has been known for decades. Anyway, in the laboratory you are certain to experience the thrill of discovering for yourself some of the principles of physics. Most of the principles of physics were discovered by men using equipment no better than yours. Most of it, in fact, was not as good. With the equipment in front of you, you have the chance to try out your own ideas, to reason about the results, and to draw conclusions from them. In brief, you should regard the laboratory as a place for *intellectual* exploration.

Before you come to the laboratory, study the laboratory manual so that you will know what you are going to do and so that you can plan in advance how to use your time efficiently. As you do the experiment, make an effort to correlate the behavior of the apparatus with the principles discussed in lecture. Pay special attention to the derivations and equations used; eventually, when you substitute values into equations, you will know why you use them.

Keep your mind open to the possibilities of the experiment. Constantly ask yourself such questions as: Why do we do it this way? What would happen if we did it another way? What does this measurement show or prove? The purpose of the laboratory manual is to direct your thinking along those channels most likely to be fruitful.

A student must realize that the laboratory work has applications outside the laboratory. For instance, the magnetometer experiment may suggest ideas in connection with the magnetic prospecting for minerals. The experiment on diffraction may help to explain why better directivity is obtained from the higher frequency radars. The experiment on optical instruments may suggest an approach to the projection of television pictures. There are, of course, innumerable other examples.

Writing laboratory reports is a significant part of your professional training. Speaking and writing are the most important tools of the engineer-scientist. Learn to handle them well. Your report should be well-organized, accurate, clear, concise, and easy to read.

Since you will have to write reports anyway, while you are doing them try to improve your command of your native language. Do not try to impress the reader with your own learning but write as if you were trying to explain the matter to an intelligent personal friend. Ability to express oneself clearly is extremely important for the professional person, even if a few people may tell you otherwise.

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

a) It's up to you whether you make the most of the laboratory work in physics or not. ( )
b) You are unlikely to discover something new during your lab work. ( )
c) It is lab work that gives you skills in the use of scientific instruments and techniques. ( )
d) Only in a well-equipped laboratory it was possible to discover all the known principles of physics. ( )
e) Studying laboratory manual is optional and not very helpful. ( )
f) Scientific or technical laboratory reports should be brief and easy to understand. ( )

Discuss

Agree or disagree with the following. Give reasons.

Study help

Make use of every opportunity you get to practice speaking in class. Discussions and role-plays help you prepare for a real-world experience.

- You should regard a laboratory as a place for intellectual exploration.
- A student must realize that the laboratory work has applications outside the laboratory.
- When doing lab work students' initiative is not encouraged.
- Writing laboratory reports is a significant part of your professional training.

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 take/see your point, but… I'm not sure… That's not true…

Focus on language

1. **Translate these words into Russian. Use a dictionary to check your translation.**

experiment	***accurate***	***student***	***intelligent***	***command***	***manual***

International words vs. "False friends"

The words mostly of Greek and Latin origin that are used in many other languages especially in different areas of science and technology are called international words, e.g. *geometry, atom, mathematics, radio, integral, theorem, structure, etc.*

Knowledge of such words helps a lot in reading and translation. However, there are the so called 'false friends". These are words that look like international but have different meanings in English and in Russian, e.g. **a list** (*a series of names, items, figures, etc*), ***actual*** *(real, existing in fact, etc), etc.*

2. **Sort out the words from the box into categories. Use a dictionary if necessary. Add some more words to each category from the text.**

International words	*"False Friends"*
lecture	*accurate*

~~lecture~~ form ~~accurate~~ technology magazine fact logic mixture repetition intelligent prospect problem actual technique example original paragraph lamp transparent focus list test category activity priority sodium application fabric metal guarantee vibration physician data encyclopaedia menu clay system probe familiar unique scheme type

LISTENING

1. **You will hear a lab instructor talking to students about the laboratory classes they will do during the semester. Answer the questions.**

   a) How many lab work classes will the students do during the semester?
   b) What are the students required to do after performing experiments?
   c) Which day of the week should lab reports be turned in?
   d) In what case can the students get a lower grade for their report?
   e) What two methods are the students going to explore when doing the labs?
   f) Which method helps to learn data analysis skills and basic laboratory skills?
   g) How many times can students be excused for being absent from the lab class?

Study help ***Taking notes***

Taking notes is an important part of the life of every student.

When you are listening or reading, taking notes helps you concentrate and make sense of the text.

Taking notes does not mean writing down every word you hear; you need to actively decide what is important and how it is related to what you have already written.

2. **Choose the correct word in the box to fill in the gaps in the interview extract. Listen to Part 2 of the talk to check your guesses.**

graphs	accurate	mistakes	nature	actively	to share
questions		experience	procedure		reports

In all aspects of this class you will be investigating the **1)** _____ of science. I believe that the best way to do this is through hands-on **2)** _____ and laboratory activities. The lab is a place for you to **3)** _____ engage in the process of 'SCIENCE'. Part of this process is writing a laboratory report. The lab report is not only the time for you **4)** _____ the results discovered during experimentation, but it is also an opportunity for you to analyze your **5)** _____, and evaluate any **6)** _____ you may have made. Remember that science is imperfect - we learn new information by trying out new things and continuing to ask **7)** _____ outside the classroom. In this class, lab **8)** _____ must always be word processed. Figures and **9)** _____ should be generated on the computer and must include a title and information about units. So, your lab reports are the most **10)** _____ and helpful record of what goes on in science class this year.

3. **Listen to the rest of the talk about the procedure of writing a lab report. As you listen, mark the components of the report in the order the speaker mentions them.**

___ Materials	___ Introduction/Purpose	___ Conclusions
___ Discussion/Analysis	___ Methods	___ Results
___ Title	___ Figures and Graphs	

4. **Listen again, take notes on the key elements of each section of the lab report and sum up this information in your own words.**

Discuss

Comment on the statements:

- When in doubt, leave it out!
- You can't explain something to someone else if you don't understand it yourself.

Focus on language

Modal verbs and their meaning

The main modal verbs are ***must, can, could, may, might, should, ought to***.

Most of the meanings of all these modal verbs can be divided into two groups:

- ✓ obligation and freedom to act, prohibition or permission, advice and ability.

e.g.

- *You **ought to/must** know how to solve this equation in order to pass you exam*. (obligation)
- ***Can** you operate this microscope?* (ability)
- ***May** I use your lab manual?* (permission)
- You ***ought to**/**should*** study harder for this difficult exam. (advice)
- You ***cannot/mustn't*** use laboratory glassware as containers for food or beverages. (prohibition)

- ✓ degrees of certainty (these modal verbs can be used to say that a situation is certain, probable, possible or impossible)

e.g.

- *You **must** be joking!/You **can't** be serious! That's just totally illogical!*
  (certainty - I'm 100% sure that this is the case.)
- *He **ought to/should be** at work now.* (probability - He is probably there. I'm 90% sure.)
- *There **could/may/might** be some changes in the timetable.* (possibility - It is theoretically possible.)
- *That **cannot be/couldn't** be the correct answer to this question.*
  (impossibility – I'm about 99% sure that it is impossible.)

1. Identify the function of the modal verbs.

Certainty Probability Impossibility Possibility
Prohibition Permission Obligation Advice Ability

a) I *can* speak English and German fluently.
b) You *can't* work with this device without protection goggles.
c) A physicist *might* work in a laboratory, designing materials for computer chips or smashing atomic particles.
d) We *ought to* take all the necessary measurements tomorrow.
e) Your hypothesis *couldn't* be proved without experiment.
f) I've done my test. *May* I go now?
g) If your lab report is not well-organized, clear and easy to read you *may* get a lower grade or *may* be asked to rewrite it.
h) You *must* be very clever if you know how to solve this equation.
i) They are not at the party, are they? They *should* be preparing for their quantum mechanics exam now.
j) If you feel you are not coping you *should* ask your tutor to help you.

SPEAKING

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

- 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.

3. **What else could you add to these lists? Hold a cross-group discussion and compare your lists.**
4. **Have you or someone you know ever had an accident in the lab? What happened?**
5. **Do you agree that "Discoveries are made by not following instructions"? Why?/Why not?**

READING

1. **Label the pictures and give definitions to the devices.**

1_____	2_____	3_____	4_____
			

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?

2. **Look at the words in the box. What parts of speech are they? Check if you know their meaning. Use a dictionary if necessary.**

• signals	• mechanical	• stability
• operate	• wireless	• rate
• positive	• frequency	• phase
• equipment	• microprocessor	• sensitive
• crystal	• fluctuation	• atomic

3. **Complete the text using the words in Task 2. Compare as a class.**

An oscillator is a **1)** _____ or electronic device that works on the principles of oscillation: a periodic **2)** _____ between two things based on changes in energy. Computers, clocks, watches, radios, and metal detectors are among the many devices that use oscillators. A clock pendulum is a simple type of mechanical oscillator. The most accurate timepiece in the world, the **3)** _____ clock keeps time according to the oscillation within atoms.

Electronic oscillators are used to generate **4)** _____ in computers, **5)** _____ receivers and transmitters, and audio-frequency **6)** _____, particularly music synthesizers.

There are many types of electronic oscillators, but they all **7)** _____ according to the same basic principle: an oscillator always employs a **8)** _____ amplifier whose output is fed back to the input in **9)** _____. Thus, the signal regenerates and sustains itself. This is known as **10)** _____ feedback. It is the same process that sometimes causes unwanted "howling" in public-address systems. The **11)** _____ at which an oscillator works is usually determined by a quartz **12)** _____. In fact, the best **13)** _____ (constancy of frequency) is obtained in oscillators that use quartz crystals.

In a computer, a specialized oscillator, called the clock, serves as a sort of pacemaker for the **14)** _____. The clock frequency (or clock speed) is usually specified in megahertz (MHz), and is an important factor in determining the **15)** _____ at which a computer can perform instructions.

Focus on language

Practice the pronunciation of these terms and give their Russian equivalents.

pendulum	['pendjuləm]	fluctuation	[flʌktju'eɪʃ(ə)n]
oscillator	['ɔsɪleɪtə]	capacitor	[kə'pæsɪtə]
audio-frequency	['ɔ:dɪəʊ 'fri:kwənsɪ]	quartz	[kwɔ:ts]
synthesizer	['sɪnθəsaɪzə(r)]	megahertz	['megəhɜ:ts]
amplifier	['æmplɪfaɪə]	phase	['feɪz]

Discuss

- Can you name a tool or a device that was used to make a significant discovery in physics?
- Has it changed since that time?
- Is it still being used in scientific research or for educational purposes?

Get real

Search the Internet to find information about one of the most advanced devices or tools used in modern physics.

WRITING

Write a brief description of this tool/device. Make sure to include the information about its parts and components, operation and application.

SPEAKING

Work as a team. Describe the tool or device from your writing task without naming it. Follow the guidelines to help your fellow students to make the right guess about the tool/device.

- ✓ what tool/device is used for
- ✓ the way it operates
- ✓ its size, parts and components
- ✓ areas of its application

Example:

This tool device is extremely important for observing/measuring…
It's very simple in operation… and it consists of…
It serves/is used to measure/to analyze/to obtain…

Summarizing

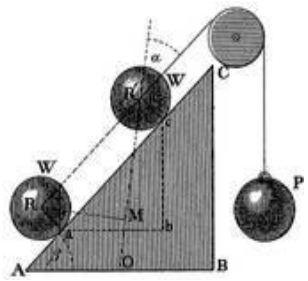
1. Read the text "Лабораторные занятия" and highlight the Russian equivalents to the English word combinations (1-13).

1) major laws of natural science
2) to reveal/manifest the essence of various natural phenomena
3) theoretical foundations/basis
4) to make observations/measurements/corrections
5) to do/conduct/carry out/perform experiments
6) to provide an experimental foundation for the theoretical concepts
7) to learn about/to understand the procedure of an experiment
8) to state the purpose of the lab work
9) to obtain/get/interpret results
10) to draw conclusions
11) to correlate what one has learned with the obtained data/results
12) to complete laboratory work
13) to organize and present results in a written report

Add new vocabulary to your vocabulary notebook. ✍

Лабораторные занятия

Усвоить многие естественные науки, в которых исследуются важнейшие законы естествознания, раскрывается сущность различных природных явлений, невозможно, изучая только теоретические основы этих наук. Необходимо провести наблюдения явлений, а для этого нужно уметь проводить эксперименты. Такие навыки приобретаются на лабораторных занятиях, практикумах и требуют дополнительной подготовки к ним.



Лабораторные работы и практикумы по физике способствуют как практическому освоению научно-теоретических основ изучаемой дисциплины, так и овладению техникой эксперимента.

При проведении опыта необходимо знать цель работы и правила пользования лабораторным оборудованием, выбирать необходимое оборудование для проведения эксперимента и выполнять измерения, оценивать погрешности полученных данных, интерпретировать результаты и делать выводы, соотносить изученный материал и полученные результаты.

Лабораторная работа считается выполненной только в том случае, когда по ней принят отчет. Чем скорее составлен отчет после проведения работы, тем меньше будет затрачено труда и времени на ее оформление.

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

In the Realm of Science

1. **Here are some of the instruments used in physics. Give their Russian 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

2. **Notes are a summary and should be much shorter than the original. So, abbreviations and symbols can be used whenever possible. Here are some conventional English symbols and abbreviations.**

and	&	important	N.B.
at	@	greater than	>
approximately	≈, approx.	less than	<
equivalent to	≡	much greater than	>>
correct	✓	much less than	<<
wrong	X	number	No. or #
decreases, falls	↘	page	p.
grows, increases	↗	results from	←
and other things	etc.	results in, leads to	→
especially	esp.	similar to	≈
for example	e.g.	uncertain, not sure	?
in other words	i.e.	with reference to	re.

Progress Monitoring

In this unit you have worked on the vocabulary on the topic: "Laboratory work".

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

1. laboratory work/manual
2. to analyze the procedure of an experiment
3. to use scientific instruments and techniques
4. to take/to make accurate measurements
5. to state the purpose of the lab work
6. to follow lab safety rules/instructions
7. to obtain/get/interpret/analyze/data or results
8. to practise the application of physical laws and logic to real cases
9. to get professional training
10. to do/perform/conduct an experiment
11. to have hands-on experience of sth
12. to experience the thrill of discovering sth
13. to have applications outside the laboratory
14. to do/complete laboratory work
15. to make observations
16. to do research/investigation
17. to organize and present results in a written report
18. to correlate what one has learnt with the obtained results
19. to suggest an approach to sth
20. to draw conclusions

Progress Test

1. **Cross out the "*false friend*" word. Explain your choices.**

   a) test, activity, instrument, logic
   b) system, vibration, application, guarantee
   c) intelligent, unique, experimental, metal
   d) type, technique, category, scheme
   e) to practise, to test, to experiment, to probe
   f) geographer, physician, engineer, programmer

2. **Give English equivalents to these Russian word combinations.**

   a) важнейшие законы естествознания
   b) получить практический опыт
   c) объяснить/сформулировать цель исследования
   d) получать/интерпретировать результаты

e) техника эксперимента

f) составить письменный отчет

g) делать выводы

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

e.g. - [ek'sperɪmənt] - опыт, эксперимент

a) ['mænjuəl]

b) ['ækjərət]

c) [prə'siːʤə]

d) [ˌɪnt(ə)'lektjuəl]

e) [haɪ'pɔθəsɪs]

f) [ɪ'kwɪpmənt]

g) ['kʌr(ə)nt]

4. Translate these sentences into Russian. Define the meaning of the modal verb in each sentence.

a) You *may* become famous if you prove the Fermat's theorem.

b) It *shouldn't* be too difficult to do a Classical Mechanics course.

c) With the help of new software scientists *can* create a more accurate model of the process.

d) *May* I ask you a question, please?

e) Students *must* register at the tutorial office in the first week of term.

f) This book *cannot* be taken out of the library.

g) We *could* observe this rare phenomenon tomorrow night if the sky is clear.

h) He *must* be right; he's an expert in this area.

i) I think you *should* come to the University Open Days to get a feel for the university and student life.

j) You *can't* do laboratory work properly without previous study of the lab manual.

UNIT 4

THE ENDLESS UNIVERSE?

"The Earth is just too small and fragile a basket for the human race to keep all its eggs in it."

Robert Heinlein

Learning Objectives

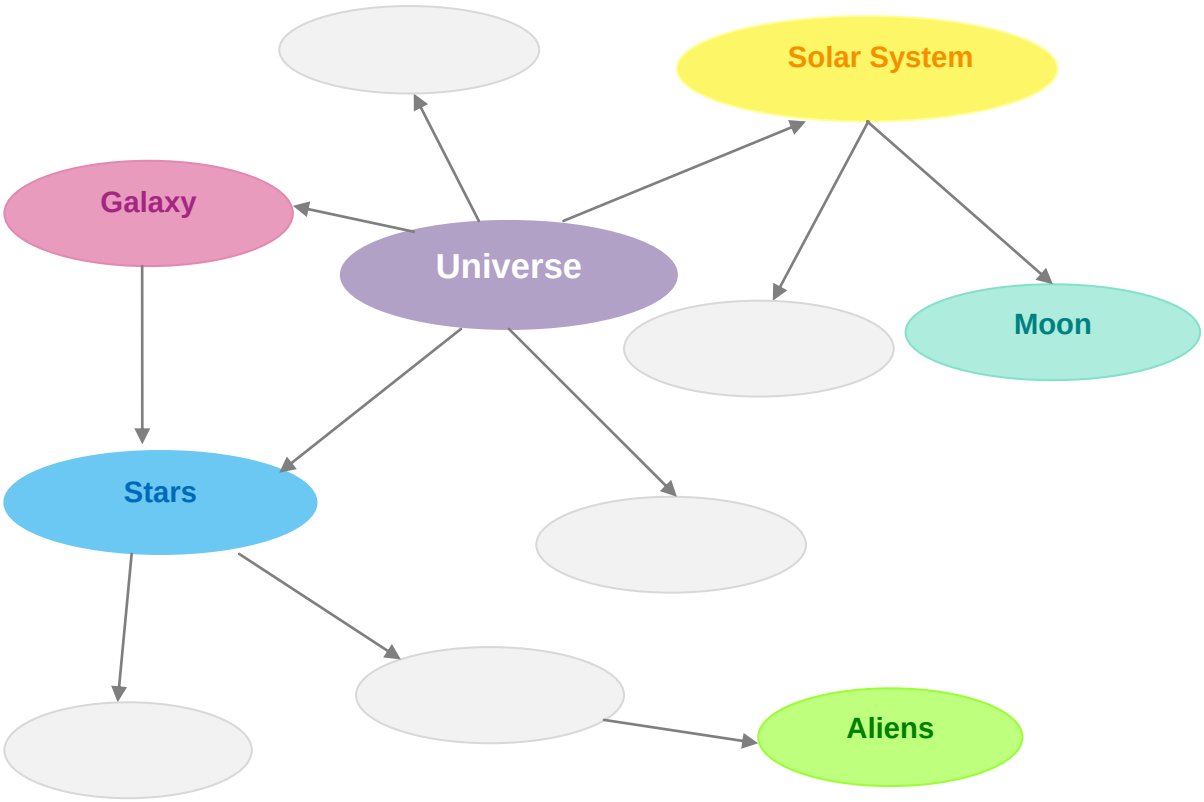
In this unit you will:

- ✓ learn the terms connected with the study of the Universe
- ✓ revisit conditional sentences
- ✓ make use of key words for efficient reading
- ✓ learn how to deliver an oral presentation
- ✓ talk about the exploration of the Universe
- ✓ write a description of the Astrophysics department for a university Prospectus

LEAD IN

1. **Work in groups. Read the definition of the 'Universe' and brainstorm as many ideas associated with this word as you can. Fill in the diagram and comment on how the ideas are connected.**

Universe ['juːnɪvɜːs] n – all space and everything that exists in it; all the stars, planets, their satellites, etc.



2. **What fields of science study the Universe?**
3. **Do you know any outstanding scientists who have studied the Universe?**
4. **What important discoveries in the study of the Universe can you name? In pairs make up a list of discoveries and compare your lists as a class.**

List of discoveries:

- ✓ Halley comet
- ✓ Black holes
- ✓ .....
- ✓ .....

READING

1. **Match the headings (*A-J*) to the texts (1-9). There is one extra heading that you don't need to use.**

A. Something "Dark"

B. "Dark" Side of the Universe Expansion

C. End of Evolution?

D. Dealing with Physical Properties

E. From Primitive to Complex

F. Does Getting Closer Always Mean Friendly?

G. Explosion Leading to Creation

H. It Studies the Universe as a Whole

I. An Endpoint or a Birth?

J. Based on Knowledge from Various Fields

Study help

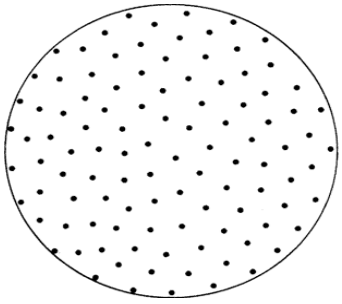
Follow these steps so that you can match the correct heading to each extract:

- read through the list of the headings
- skim all the extracts
- look for topic sentences and key words in each extract
- select the right heading

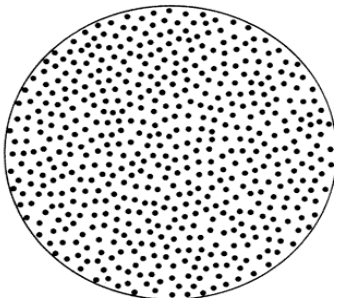
1) Cosmology is the study of the universe as a whole, including theories about its origin, evolution, large-scale structure, and future.

2) Space exploration, or astronautics, is an interdisciplinary area. It draws upon the findings of such fields as physics, astronomy, mathematics, chemistry, biology, medicine, electronics, and meteorology.

3) In 1948 the American physicist of Russian origin George Gamow proposed that the universe was created in a gigantic explosion and that various elements observed today were produced within the first few minutes after the Big Bang, when the extremely high temperature and density of the universe would fuse subatomic particles into the chemical elements.



Model of an early stage of an expanding universe: the universe is homogeneous.



Model of a later stage of an expanding universe: new galaxies emerge continually within the expanding space.

4) In the beginning, soon after the Big Bang, the cosmic gas was distributed extremely uniformly and consisted only of the most primitive chemical elements: hydrogen, helium and lithium. The present-day universe, on the other hand, is full of complexity and structure. Some researchers think that this transition from simplicity to complexity originated in quantum-mechanical processes, whereby tiny perturbations of the vacuum state led to density fluctuations in the very early universe. These fluctuations have been amplified by gravity, and so led to the birth of a hierarchy of gravitationally bound structures from the smallest galaxies to groups, clusters and super clusters of galaxies.

5) The Tunguska event occurred in 1908, when a meteor or comet exploded over the wilderness of Siberia, damaging farmland and trees for miles around.
Because most of the earth is covered by oceans, there may be small impacts that go unnoticed.
When a new asteroid is discovered, astronomers analyze it to determine whether its orbit around the sun could bring it close to the Earth.

6) Observations made by Edwin Hubble revealed that the universe is not static, but is expanding. What's more, recent observations of distant supernovae indicate that something is accelerating that expansion. Cosmologists assume that this expansion is caused by "dark energy" that spreads into every part of the universe, corresponding to a small, positive value for the cosmological constant.

7) Previously, black holes were seen as the endpoints of evolution, the final resting state of most or all of the matter in the universe. Now some scientists believe that black holes also play a critical role in the birth of galaxies. They have got some evidence that galaxies actually did form around the earliest black holes.

8) Astrophysics is the branch of astronomy that deals with the physics of the universe, including the physical properties (luminosity, density, temperature and chemical composition) of astronomical objects such as stars, galaxies, and the interstellar medium, as well as their interactions.

9) Dark energy is the mysterious stuff that is stretching space and speeding the expansion of the universe.
Still, no one can explain precisely what dark energy is. It could be a kind of continual pressure woven into the fabric of space itself, a concept known as a cosmological constant and dreamt up by Einstein. If so, then the amount of dark energy would grow with expanding space so that each cubic centimeter always contains the same constant amount.
Alternatively, dark energy could be some new sort of field, a bit like an electric field, that fills space and grows weaker and more dilute as space expands.

2. Choose the best answer (*a, b,* c or *d*) to answer the questions (1-5).

1) Which science studies the origin, evolution, large-scale structure, and future of the universe?

a) astrophysics
b) cosmology
c) astronomy
d) astronautics

2) Which science studies such properties of the Universe as luminosity, density, temperature, and chemical composition of astronomical objects?

a) cosmology
b) meteorology
c) astronomy
d) astrophysics

3) Which is true? The Big Bang is …

a) a super cluster of galaxies.
b) a gigantic explosion that created the universe.
c) the name of the meteor/asteroid that exploded over Siberia.
d) the hierarchy of gravitationally bound structures in the universe.

4) Which of the statements is false?

a) In the early universe the cosmic gas was composed of the most primitive chemical elements.
b) Observations of Edwin Hubble didn't prove the dynamic nature of the universe.
c) The current universe is complex and structured.
d) The transition from simplicity to complexity was caused by density fluctuations in the universe.

5) Which of the following is not true? Dark energy could be …

a) the final resting state of the matter in the universe.
b) some new kind of field in the space.
c) a cosmological constant that spreads into every part of the universe.
d) a kind of continual pressure that causes the expansion of the universe.

Focus on language

1. Study the words in the box and classify them under the headings (1-3).

1) ***Fields of science***: astrophysics
2) ***General science words***: observation
3) ***Terms connected with the study of the Universe***: dark energy

element	mathematics	astronautics
cosmology	theory	interstellar medium
supernova	property	particle
asteroid	luminosity	perturbation
medicine	black holes	physics
pressure	chemistry	density fluctuation
hydrogen	meteorology	astronomy
evolution	universe	orbit
galaxy	concept	biology

2. **Look back in the texts (1-9) in *Reading* and pick up more words to add to the lists under each heading (1-3) in Task 1. Look them up in a dictionary for pronunciation and meaning.**

Add new vocabulary to your vocabulary notebook. ✍

Get real

Search the Internet and/or popular science magazines to find out more about current studies of the Universe. Choose the one you find most interesting and make a seven-minute PowerPoint presentation about it. Use these questions as the guidelines.

- ✓ **What is being investigated?**
- ✓ **Who is doing the research?**
- ✓ **How long has it been under way?**
- ✓ **What are the purpose and the novelty of the research?**

Study help

PowerPoint is an efficient tool for presentation, if it includes well-crafted slides, useful animations and appropriate graphics.
Avoid slides cluttered with too much information and poor choices of :

- fonts, backgrounds or colours
- graphics and animations
- transition and sound effects

SPEAKING

Make your presentation in class and encourage the rest of the group to ask questions.

Functional language ***Inviting questions***

Please stop me at any time if you have any questions.
If you have any questions or comments, I'll be happy to answer them.
If there are any questions, I'll do my best to answer them.
Are there any more questions?

Focus on language

1st and 2nd type Conditional Sentences

1st type Conditional Sentences are real and about the future.
*If clause (**Present Simple**) + main clause **(Future Simple)***

e.g.

- If we **study** the rock samples from the Moon, we **will learn** more about the early days of the Earth.
- You **won't get** a high score in this subject **if** you **don't do** lab work.

2nd type Conditional Sentences are unreal and about the present.
*If clause (**Past Simple**) + main clause (**would/could +verb1**)*

e.g.

- If I **had** all the necessary data, I **would/could build** the model of the process.
- If I **were** you, I **would specialize** in astrophysics.

1. **Put the verb in the correct form. Translate the sentences into Russian.**

   Example:

   - If I ***knew*** *(know)* Mary's address, I would visit her.
   - If they participate in this conference, they ***will get*** *(get)* a very useful experience.

a) If he _____ *(get)* the promotion, it will be because he does a good job.
b) The teacher will not accept our work if we _____ *(turn)* it in late.
c) If I were you, I _____ (*attend*) definitely the lecture of this visiting professor.
d) If scientists _____ *(build)* the time machine, we could travel to any century of our history.
e) People _____ *(travel)* to other planets if they had more advanced space technologies.
f) If I finish my degree project by April, I _____ *(present)* the results at the conference.
g) You will get more accurate data if you _____ *(use)* this equation.
h) Would you contact an alien if you _____ *(have)* a chance to do so?
i) If you _____ *(not update)* the antivirus software, your computer will be much more vulnerable to malware.
j) If the alternative energy sources _____ *(be)* cheaper and more efficient, they would definitely become mainstream power resources.

LISTENING

1. **Listen to the interview with the astrophysicist Professor Brown about the planet Earth and the possibility of the existence of other intelligent life forms in our universe. Answer the questions.**

   - What makes the Earth suitable for life?
   - How does Professor Brown compare Earth with two other planets closest to it - Venus and Mars?
   - Why are Venus and Mars not able to sustain life?
   - What does SETI stand for?

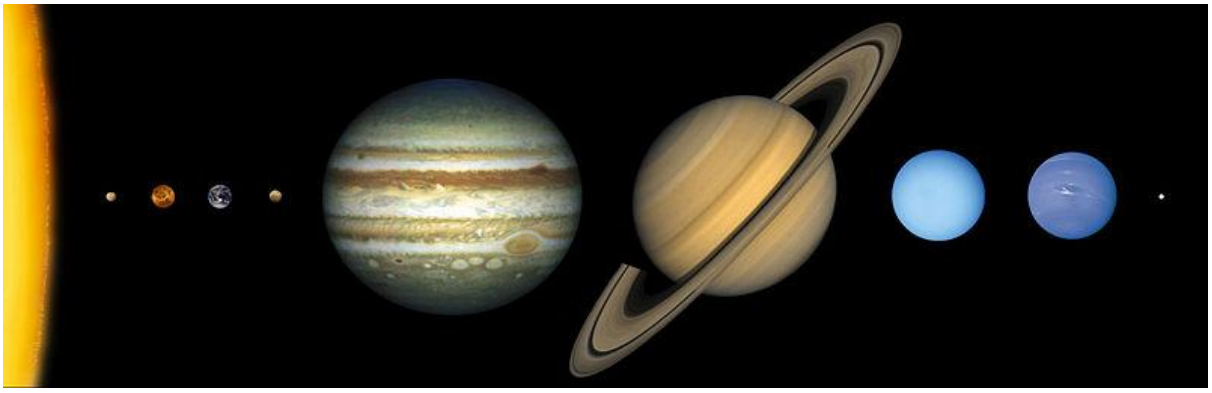
2. **Listen again and fill in the gaps in this interview extract.**

First of all the **1)** _____ of the Earth in relation to the Sun makes it the only planet obviously **2)** _____ of sustaining life right now. If we were any nearer to the Sun, the **3)** _____ would form a thick layer of cloud around us; this in turn would **4)** _____ the heat, further increasing the temperature. Within a comparatively short time, the Earth would turn into a hot and dry **5)** _____ - much like Venus that is unsuitable for life.

On the other hand, if we were any **6)** _____ from the Sun, there would not be enough heat to prevent water from **7)** _____. Before long the Earth would become an **8)** _____ wasteland like the Mars.

3. **Summarize the information you have learned in the listening task and give a detailed answer to the question: "What makes the Earth suitable for life?" Make use of the picture and speak on the following:**

   - **Position of the Earth**
   - **Size of the Earth**



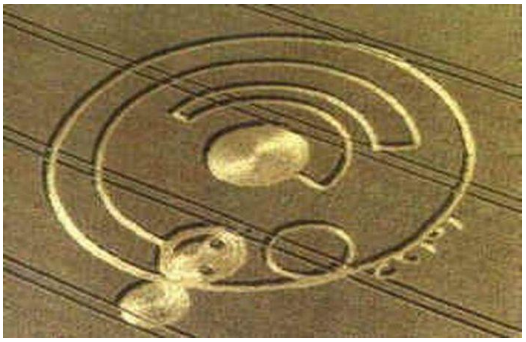
Discuss

- There are many people who claim to have seen unidentified flying objects (UFOs). What do you think of such statements?
- What is usually considered to be the evidence or signs of extraterrestrial activities on the Earth?
- Have you ever seen anything unusual that could be connected with alien activity? What was it like?

READING

1. **Look at the pictures (1-6) and match them with the words (a-f) from the list**.

1) _____



2) _____

3) _____

4) _____

5) _____

6) _____

a) UFO sighting
b) Grey alien
c) Crop circle
d) Flying saucer
e) Giza Pyramid
f) Stonehenge

2. **Match the definitions (1-6) with the words (a-f) in Task 1.**

1) a very large stone structure, which was used as a burial place of pharaohs.
2) off-planet beings with large almond eyes and hairless grey skin.
3) a group of very large, tall stones that are arranged into a large circle with a smaller circle inside it, which stand on Sainsbury Plain in southern England. It is believed they were put there about 4000 years ago and were used for studying the movements of the Sun, Moon, and stars.
4) viewing of an extraterrestrial craft or other unidentified object.
5) any of a variety of patterns that began appearing in the fields of farms in England and some other European countries in the late 1980s and 1990s. Some people think they are the work of beings from outside the Earth.
6) usually a plate-shaped spaceship which is said to be piloted by creatures from another world.

3. **Read the text about some possible evidence of alien activity on our planet. Complete the sentences with the information from the text.**

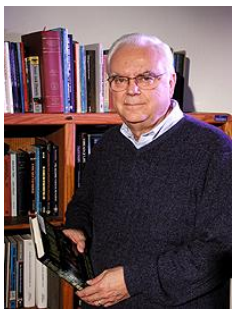
a) The Egyptian pyramids, which date back to around 10500-8000 BC, provide evidence that…
b) Some of the world wonders are believed to have been created by…
c) SETI stands for …
d) "Drake Equation" allows researchers to calculate…
e) Space travel to even the nearest stars is currently absolutely impossible because…
f) Some scientists are quite sceptical about UFO sightings and crop circles because in their opinion they could …

Do They Exist?

The Earth has undergone and still undergoes anomalies which have neither been justified by historical standards nor explained by science. The pyramids and the Sphinx at Giza, Egypt, date back to around 10500-8000 BC, which proves that a highly advanced but unrecorded civilization existed at that time. The exact alignment of the Giza pyramids to the three stars of Orion's Belt reflects the interest of that culture in astronomy. This is also supported by the findings at Stonehenge, where it has been established that wooden totem poles, dated as far back as 8000 BC, are a sort of astronomical marker, a forerunner to the stone observatory built in 2700 BC.

Those who believe in the existence of extraterrestrial life assume that these wonders were built by beings from some other planets that were advanced enough to travel to Earth and make it their station.

The search for extraterrestrial intelligence (SETI) is a scientific investigation into possible communication signals originating from an extraterrestrial civilization.



In the early 1960s Frank Drake came up with an equation (called the "Drake Equation") N = R * f*p* * *ne* * f*l* * f*i* * f*c* * L that calculated the possibility of extraterrestrial life. He determined that there was a possibility of 100,000 to 1,000,000 extraterrestrial civilizations in our galaxy (the Milky Way) alone. With so many complex and huge solar systems across the galaxy, the Earth cannot be the centre of the universe. If it is true, then what is the purpose of the rest of the huge universe?

The most conclusive and most satisfying way of finding life beyond the Earth would be to meet aliens from another planet. But unless they happen to visit us, this is extremely unlikely. Space travel to even the nearest star, Alpha Centauri, is at present totally impossible due to the distances involved; modern spacecraft can only travel at about 36,000 km per hour. At this speed it would take 12,000 years to reach Alpha Centaury; reaching another planet belonging to a sun-like star would take even longer.

Sightings of 'UFOs' - biblical and historic references to ‘flaming chariots’, huge flying 'birds' and odd-looking beings have been reported throughout history. But most scientists pay little attention to UFO sightings, believing them to have either a rational explanation or to be a figment of the imagination. The formation of crop circles in different parts of the world has also been discredited as evidence of alien activity. They are considered either to be a freak natural phenomenon or the work of hoaxers. Even less credence is given to some people’s claims to have been abducted by aliens.

It will probably take some more time and more public participation to determine the truth. If there are extraterrestrials, then we have already lost a lot of time by not accepting their presence. There's truth waiting to be discovered outside the circle of our compact lives.

Summarizing

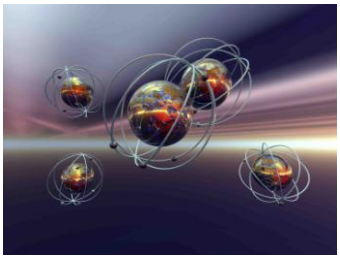
1. **Read the text “Струны в космосе” and highlight the Russian equivalents to the English word combinations (1- 14).**

1) standard cosmological model
2) to be a result of the cosmic explosion (Big Bang)
3) fragments keep scattering
4) to expand/shrink (about the Universe)
5) to result in a powerful cosmic explosion
6) to look at something in a reverse order
7) to vanish in a black hole
8) to shrink into infinitesimal point
9) string theory
10) to explain the origin of the Universe
11) transient stage
12) death and birth cycles
13) tiny string
14) increased density led to the formation of black holes

Струны в космосе

Согласно доминирующей сегодня теории (Стандартной космологической модели), Вселенная образовалась в результате космического взрыва (Большого взрыва). Это произошло около 15 миллиардов лет назад. Но даже сегодня продолжают разлетаться «осколки» этого взрыва, представляющие собой миллиарды галактик. Вселенная расширяется.

Однако ученые не знают, будет ли она расширяться всегда или в какой-то момент она начнет опять сжиматься, что впоследствии вновь приведет к мощному космическому взрыву. Если бы мы смогли просмотреть космическую историю в обратном порядке, то увидели бы, как все галактики проваливались в черную дыру и сжимались в единственную бесконечно малую точку. Физики называют эту точку сингулярностью. В тот момент, когда вся Вселенная сжалась в сингулярность, наша космическая история закончилась бы.



Теория струн по-новому объясняет, как произошла наша Вселенная. «Струнные» физики утверждают, что Большой взрыв был не моментом, когда возникла Вселенная, а просто переходной стадией. Согласно теории струн, Вселенная существовала всегда. В отдаленном прошлом она была почти пуста. К моменту Большого взрыва Вселенная могла пройти несколько циклов гибели и возрождения (расширения и сжатия). До Большого взрыва такие силы, как гравитация, были слабы. Они постепенно росли, и материя начала сжиматься. Но, согласно теории струн, она сжималась не до бесконечно малой точки, а до крохотной длины струны. В некоторых областях Вселенной плотность возросла настолько, что начали формироваться черные дыры. Дыры разрастались, ускоряясь. Они стягивали материю все плотнее и плотнее. Когда материя стала такой плотной, что не могла больше сжиматься, произошел Большой взрыв. Дальнейший сценарий развития нашей Вселенной у «струнных» физиков не отличается от Стандартной космологической модели.

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

Project Work

1. **Work in groups of four. Collect information about the Cosmology/Astrophysics Department at your faculty/university. Find information about:**

- ✓ the date of its foundation and the leading researchers
- ✓ the major areas of current research
- ✓ facilities of the department (laboratories, equipment, research schools and traditions, etc.)
- ✓ most notable achievements

2. **Report your findings to the class.**

Study help ***Making a group presentation***

When you make your group presentation, follow this procedure:

- one student introduces the group and gives an introduction of the work conducted by the group.
- the next few students present one or two of the points and some interesting comments.
- the last student concludes the presentation by summarizing and interpreting the information.

WRITING

Use the information from the *Project work* and write a short description of the Cosmology or Astrophysics Department for the University Prospectus.

In the Realm of Science

Learn how to say the names of some nebular objects in the Solar System.

Mercury	['mɜːkj(ə)rɪ, 'mɜːkjurɪ]	Saturn	[' sætən]
Venus	['viːnəs]	Titan	['taɪt(ə)n]
Earth	[ɜːθ]	Uranus	['juər(ə)nəs]
Moon	[muːn]	Neptune	['neptjuːn]
Mars	[maːz]	Pluto	['pluːtəʊ]
Jupiter	[' ʤuːpɪtə]		

Progress Monitoring

In this unit you have worked on the vocabulary on the topic: "Universe Exploration".

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

1. to be created in a gigantic explosion
2. perturbations of the vacuum state
3. density fluctuations in the universe
4. transition from simplicity to complexity
5. hierarchy of structures
6. clusters/super clusters of galaxies
7. to speed/ to accelerate the expansion of the universe
8. to play a critical role in the birth of galaxies
9. to get some evidence of sth
10. to stretch space
11. cosmological constant
12. to sustain life
13. highly advanced civilization
14. to believe in the existence of extraterrestrial life
15. SETI (search for extra-terrestrial intelligence)
16. to have a rational explanation
17. to be discredited as evidence of alien activity
18. to be abducted by aliens
19. to expand/to shrink
20. astronomical/nebular objects

Progress Test

1. **Cross out the odd word. Explain your choices.**
   a) astrophysics, chemistry, cosmology, astronomy
   b) asteroid, supernova, meteor, comet
   c) observation, equation, concept, theory,
   d) hydrogen, matter, helium, lithium
   e) complexity, density, anomaly, luminosity
   f) aliens, UFOs, extraterrestrials, hoaxers

2. Give English equivalents to these Russian word combinations.

a) расширяться/сжиматься
b) приводить к взрыву
c) теория струн
d) происхождение вселенной
e) «провалиться» в черную дыру
f) формирование чёрных дыр
g) переходная стадия

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

e.g. ['orɪʤɪn] – origin - происхождение

a) [ʤaɪ'gæntɪk]
b) [ˌpɜ:t ə'beɪʃən]
c) [ˌflʌktʃu'eɪʃən]
d) ['haɪəra:kɪ]
e) [dɪ'tɜ:mɪn]
f) [ˌɪnfɪnɪ'tesɪm(ə)l]
g) [ˌekstrətə'restrɪəl]

4. Three of these sentences are correct. Write (V) by the correct sentences, and (X) by the incorrect ones. Rewrite the three wrong sentences in correct English.

a) If the Earth is any nearer to the sun, the heat would form a thick layer of cloud around it. ( )
b) A wire carrying a current will rotate if it is placed in a magnetic field. ( )
c) There would not be enough heat to prevent water from freezing if the Earth was any further away from the sun. ( )
d) If I won't pass my exam, I'll be very disappointed. ( )
e) Any object moved toward Earth's centre if it is placed in Earth's gravitational field. ( )
f) If I remembered the formula we could solve this problem now. ( )

UNIT 5

CUTTING EDGE PHYSICS

"The important thing in science is not so much to obtain new facts as to discover new ways of thinking about them."

Sir William Bragg (1862 - 1942)

Learning Objectives

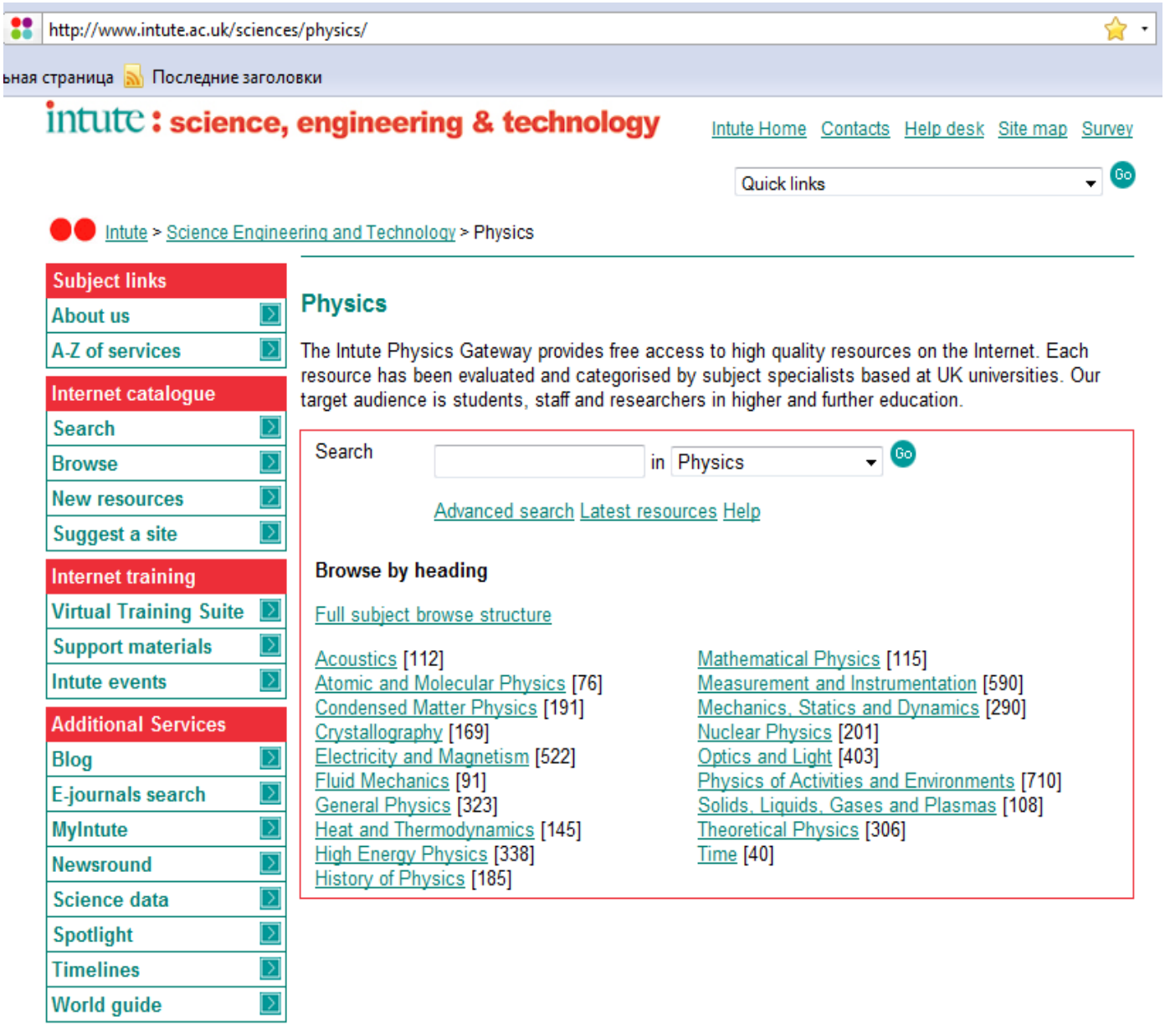
In this unit you will:

- ✓ learn some expressions for narrating and reporting
- ✓ revisit Passive structures
- ✓ talk about the latest achievements in physics
- ✓ write a summary of an article
- ✓ learn to express facts and opinion in writing
- ✓ prepare and give a talk at a conference

LEAD IN

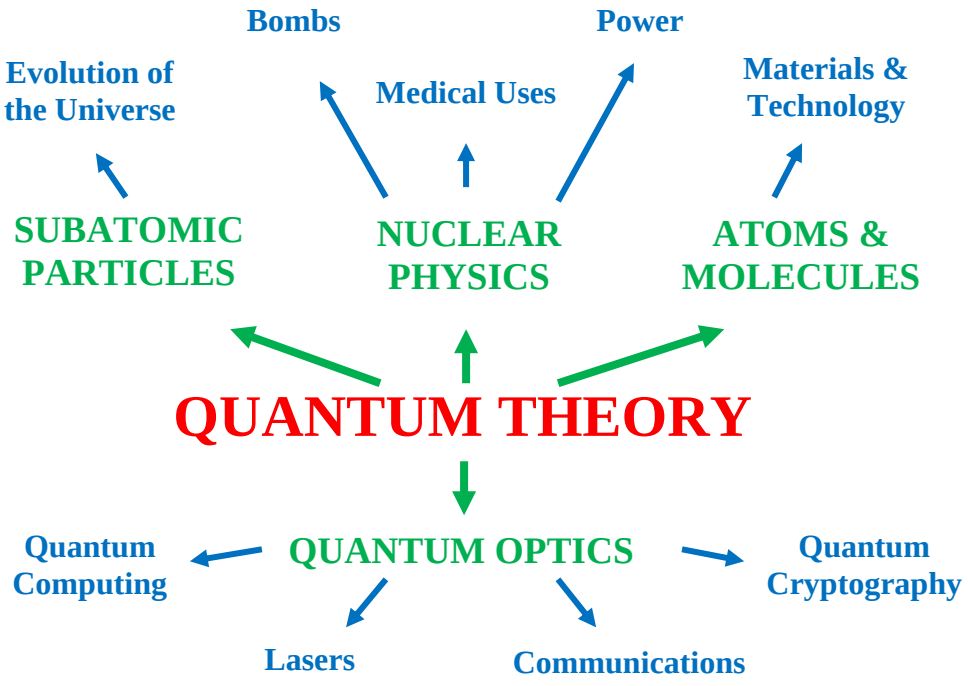
1. **Look at the screenshot of the Internet site and answer the questions.**

   - What kind of information does the website provide?
   - Are you taking now or are you going to take a course in any of the fields of physics listed on the webpage? What natural phenomena do these fields study?
   - Which field of physics would you like to specialize in?



2. **Work in pairs. 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.

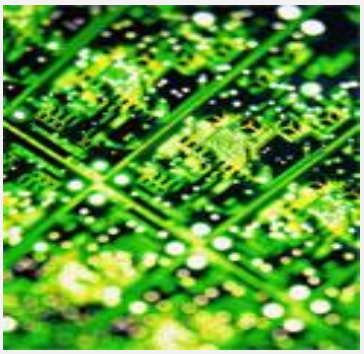
Example:



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

A _____

B_____



C_____

D_____

E_____

F_____

READING

1. **Read the text about the breakthroughs of the 20th century physics. Find out what changes they have brought about. Complete the chart.**

Breakthrough	Implication
✓	✓ .....
✓	✓ .....
✓ Roentgen's discovery of X-rays	✓ medical imaging
✓	✓ .....
✓	✓ .....
✓	✓ .....
✓ etc.	✓ etc.

2. **Answer the questions.**

a) What breakthroughs laid the foundations of the 'new era' in physics?
b) What factors play a key role in the development of experimental physics?
c) What does "Big Science" require?
d) What are some of the valuable spinoffs of pure and applied research?
e) How are lasers being applied?
f) Why is scientific and technological development crucial for a nation's prosperity?

Focus on language

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

a) extraordinary, first-time, exceptional
b) modern, current, present-day
c) importance, effect, result
d) in the end, eventually, finally
e) resourcefulness, originality, inventiveness
f) pioneering, inventive, novel
g) enormous, gigantic, massive
h) precious, important, helpful
i) amazing, overwhelming, shocking
j) fundamental, essential, critical

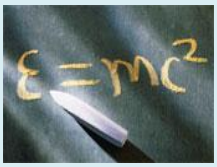
2. **Find in the text nouns that collocate with these words.**

a) conceptual and intellectual/scientific and technological …
b) technological …
c) innovative …
d) pure/applied …
e) international …
f) powerful …
g) to revolutionize …
h) physics-based…
i) national …
j) high academic …

Add new vocabulary to your vocabulary notebook. ✍

THE ADVANCES AND BREAKTHROUGHS OF 20TH - CENTURY PHYSICS

The past seventy years of development in physics have seen a period of unprecedented conceptual and intellectual development. The contemporary physics revolution, based on the discovery of the electron, the theory of relativity and quantum theory, has led science into a new era.



The first few decades of the twentieth century uncovered the implications of relativity and quantum mechanics. For many generations of twentieth-century physicists, relativity and quantum mechanics were the "New Physics". The Universe is governed ultimately by probabilities. The implications of this uncertainty began to take root soon after the discovery of quantum mechanics, but it took several decades before other important concepts such as quantum entanglement* were understood and demonstrated.

Experimental physics is firmly planted in ingenuity*, and new discoveries can often be sparked by technological breakthroughs and innovative instrumentation. In the twentieth century, the liquefaction of helium opened the door to the cryogenic world of superconductivity and superfluidity.

Later in the twentieth century, World War II brought major advances in nuclear physics, microwave techniques, and digital computers. This was initially science applied to the war effort, but with the war over, pure science gained a huge reward from these advances. The scale of this applied science had also set a new scale for pure research. "Big Science" had arrived, requiring massive support and international collaboration. Space research is a good example. Cosmology has now become an experimental science as well as a theoretical one.

Nowadays new international collaborations focus on the long-term goal of controlling thermonuclear fusion as well as on construction of enormous high-energy accelerators. These will be used in areas of science beyond particle physics, from molecular biology to nanotechnology.

On a smaller scale, applied physics laboratories such as Bell Labs and IBM Research have made a great number of pure-science breakthroughs such as semiconductors and transistors, with a major impact on industry and lifestyle.

However, pure research can also bring valuable spinoffs – a classic example being Roentgen's discovery of X-rays, which were used for medical imaging even before the atomic-physics origin of this radiation had become clear.

In another sphere, the advent of modern telecommunications and the ready availability of powerful computers have revolutionized research methods. No longer do scientists have to work alone in isolated laboratories. At CERN, the European particle-physics laboratory in Geneva, Switzerland, the World Wide Web was developed in the late 1980s to enable scientists to access research information remotely and share it with their colleagues via the Internet, without necessarily having to come to the laboratory. All in all, the development of computation and computer techniques has been staggering.

Invented only some sixty years ago, the transistor has become the quantum of modern electronics. Another example of a physics-based applications explosion is the laser, invented a decade after the transistor, but which now plays a key role in storing and retrieving digital data in increasingly compact forms. They are widely used in home and office electronics equipment, and are extensively employed in medicine for microsurgery. Lasers have also opened up new areas of physics and enable ultra-precision measurement to be made.

There is another reason for appreciating modern physics. Because it is the basis of Nature, understanding this science is a vital component of today's civilization. There is a correlation between physics capability and national prosperity. Training new physicists will not immediately make nations more prosperous, but an intellectual core community is needed to ensure high academic standards and catalyze scientific and technological development.

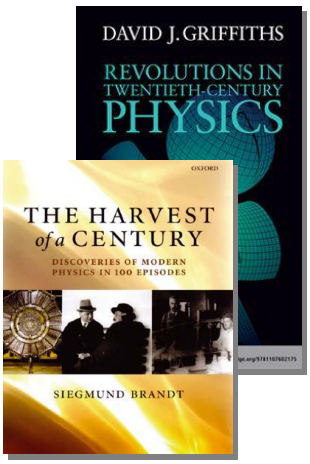
*quantum entanglement – квантовая запутанность
*ingenuity - изобретательность, искусность

Discuss

- Who are the 'big names' in the 20th century physics?
- How many Nobel Prize winners among them can you name?
- What fields of physics did they work in? What was their contribution to the scientific and technological development?
- Are there any 21st century breakthroughs in physics? What are they?

SPEAKING

Summarize the information from the text you have read on the advances in 20th-century physics. Follow the guidelines:



- ✓ Identify the key points of the text and the supporting details the author uses to illustrate them.
- ✓ Summarize the key points and the supporting details in your own words.
- ✓ Arrange your information in a logical order. Make use of the appropriate linking words.
- ✓ State the title of the text in the very first sentence of your summary as well as the source it comes from and the author' name (if they are available).
- ✓ Express your opinion on the information presented in the text.

Functional language	***Summarizing***		
The text/The article	**was written by …** **was published in …**	**was presented at …** **comes from …**	
The article/The text **The author**	**discusses … describes … informs on/about …** **considers/deals with the problem of …**		
It is reported/said/stated that…	**It is pointed out/claimed that…**		
Actually; In fact; In particular; For example;	**Also; Moreover; However; All in all; Finally, etc.**		
The information presented in the …	**is very interesting because …** **is widely-discussed in the press because …**		
The problem	**is the most up-to-date/urgent as it …**		
I find the information of	**great** **particular** **general** **little** **no**	**interest** **value** **significance**	**because …**

Focus on language

Passive Structures **be + V3**

- Passive verbs are common when we are not interested in **who** carries out an action or it is **not necessary** to know.

e.g. *Entirely new phenomena have been discovered and well known effects have been studied with increasing precision.*

- Use **by** … only if it is necessary to say who does/did the action.

e.g. *The original idea of atoms was developed **by** Niels Bohr.*

- In the passive sentence the grammatical subject receives the focus.
- The passive is often used to describe processes and procedures.

e.g. *Finally, the light is detected and converted into an electronic signal with a compact solid state photo sensor.*

- Passives are best in formal or impersonal style.

1. **Look back in the text and mark all the passive structures. Translate the sentences with the passive verbs into Russian.**

2. **Here is the beginning of an experiment report. Rewrite it in passive and make all the necessary changes.**

In this investigation, we examined the hypothesis that the circumference (C) and diameter (D) of a circle are directly proportional. We measured the circumference and diameter of five circular objects ranging from 2 cm to 7 cm in diameter. We used vernier calipers* to measure the diameter of each object and we wrapped a piece of paper around each cylinder to determine its circumference. However, we analyzed only a narrow range of circle sizes, so one should take additional data to investigate whether the constant ratio hypothesis applies to very large and very small circles. The results show …

*vernier calipers - эллипсограф; штангенциркуль

LISTENING

1. **Match the words in *A* with the definitions in *B*.**

A	B
1) mind-boggling	a) a stupid or careless mistake
2) to untangle	b) to remind people of a person or an event from the past
3) outburst	c) doing sth rather than just talking about it
4) blunder	d) a sudden increase in a particular activity or attitude
5) hands-on	e) very difficult to imagine or to understand; extremely surprising
6) to commemorate	f) to make sth that is complicated or confusing easier to deal with or understand

2. **You are going to hear a talk about the conference on physics.**
As you listen take notes under these headings.

a) when and where the conference was held
b) the participants of the conference
c) cutting-edge topics that were discussed
d) the invited audience

3. **Listen again and mark the statements *T* for 'true' and *F* for 'false'. Correct the false ones.**

a) In 1905 Einstein published one of his popular papers. ( )
b) One hundred years later, the United Nations declared 2005 "The World Year of Physics". ( )
c) A great number of conferences, meetings and educational workshops were held around the world to clarify some of the implications of Einstein's theories. ( )
d) The conference organized by NASA's Marshall Space Flight Center was largely space-oriented. ( )
e) Among the speakers there were two Nobel Laureates. ( )
f) Leon Lederman was awarded the Nobel Prize for his work on neutrinos. ( )
g) Top scientists and select professionals were the target audience of the conference. ( )
h) On the final day of the conference a panel discussion was devoted to unsolved problems in physics. ( )

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***

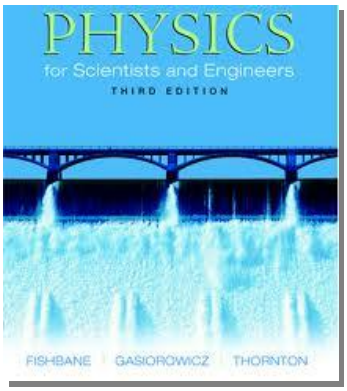
It is important when reading or writing to recognize and understand the relationship in which sentences and groups of sentences combine to present information.

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

READING

1. **Read the descriptions of the web links for physicists (*A*-*E*) and match them with the headings (1-5).**



1) **Astrophysics Spectator**
2) **National Physical Laboratory (NPL)**
3) **Introduction to Modern Solid State Physics**
4) **Open Course Ware**
5) **Biosensors and Bioelectronics**

(A) This Web page offers a comprehensive set of lecture notes, problems and solutions provided for the course: _____. Written by Professor Yuri Galperin, Department of Physics, University of Oslo, the text can be viewed either as individual chapters or as a whole in PDF format. The notes cover the basic concepts of lattices and vibrations, statistics and thermodynamics of metals and semiconductors, basics of quantum transport and superconductivity. An appendix provides further information on band structure of semiconductors, mathematical relations including trigonometry, vectors and matrices.

http://folk.uio.no/yurig/fys448/Fys448.html

(B) The journal _____, published by Elsevier Science, is an interdisciplinary journal. It is aimed at professionals with an interest in the exploitation of biological materials in novel diagnostic and electronic devices. The journal's website includes contents pages and abstracts, and subscription details. Access to full-text is restricted to subscribers. Students should check whether their university/academic institution is a subscriber.

http://www.elsevier.com/wps/find/journaldescription.cws_home/405913/descrip

(C)

_____ provides measurement services to government and industry covering: acoustics; analytical measurement; basic metrology; electrical and electromagnetic measurement; mathematics and scientific computing; ionising radiation; length; materials; mechanical metrology; optical radiation; photonics; thermal metrology and time. This extensive site contains information about the programmes and services offered by the laboratory in the fields of measurement and materials science. Publications including newsletters, beginners' guides, press releases and the annual review are available online, some in PDF format. Case studies are given to show examples of the laboratory's work in different sectors. A careers section giving vacancies and case studies is available. Also available are details of metrology clubs which bring together academics, companies and user groups through meetings, working groups and/or contact via the Internet to share and solve technical problems.

http://www.npl.co.uk/

(D) _____, written by the astrophysicist Dr Jerome James Brainerd and published bimonthly, aims to present "to a general audience our current understanding of and research in astrophysics". It covers topics from planetary physics to cosmology and includes Java applets that simulate astrophysical processes.

http://www.astrophysicsspectator.com/

(E) The MIT _____ project is a free resource from the Massachusetts Institute of Technology which offers access to many of the courses taught in the institute. This site by the Department of Nuclear Science and Engineering provides lecture notes and problem sets for a graduate course in applied nuclear physics by Professor Sidney Yip. The lectures cover the topics: basic nuclear concepts, quantum mechanical description of nuclei, the nuclear force, nuclear shell model, nuclear binding, nuclear stability and decay, interaction of charged particles with matter, interactions of neutrons with matter, interaction of gamma radiation with matter and nuclear processes. The lectures are in PDF format.

http://ocw.mit.edu/OcwWeb/Nuclear-Engineering/22-101Fall-2006/CourseHome/in

2. **Answer the questions.**

a) Which website would be most useful for specialists in the fields of measurement and materials science?
b) Who are the target audience of the ***MIT Open Course Ware project?***
c) What is the title of the course given by professor Galperin? What does the course focus on?
d) Which of the online resources would be of special interest for interdisciplinary researchers? What areas does it cover? Is there any access restriction to the site?
e) How often is ***"The Astrophysics Spectator"*** published? What is the purpose of this online resource?

Focus on language

Look back in the texts (*A-E*) to find noun phrases which are terms or general science words. Write them under the appropriate model. Translate the phrases into Russian.

Example:

application of biosensors	lecture notes	academic institution
применение биологических датчиков	конспект лекций	учебное заведение

Summarizing

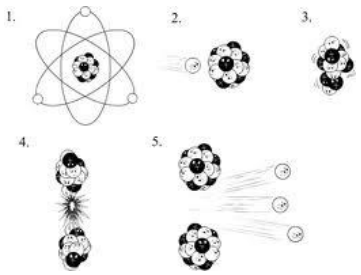
1. **Read the text «Великие достижения в физике 20 века» and highlight the Russian equivalents to the English word combinations (1-11).**

   1) uranium fission
   2) semiconductor physics
   3) to create nuclear weapons
   4) atomic/nuclear power engineering
   5) theory of superconductivity
   6) to be widely applied
   7) semiconductor heterostructures
   8) a single crystal
   9) the main component of fiber-optic communication(s)
   10) the basis for further scientific and technological development
   11) quantum dots

Add new vocabulary to your vocabulary notebook. ✍

Великие достижения в физике XX века

Можно сказать, что минувшее XX столетие было веком физики и, прежде всего, квантовой физики. Какие же открытия определили ушедший XX век? Это открытие деления урана, ряд открытий в физике полупроводников и изобретение лазера.



Открытие деления урана и создание ядерного оружия, а затем и ядерной энергетики сыграли огромную роль в истории XX столетия. Сегодня, несмотря на чернобыльскую трагедию, можно с уверенностью сказать, что нам не обойтись без интенсивного развития ядерной энергетики, потому что источники нефти и газа ограничены.

Другими важными событиями XX века стали открытие сверхпроводимости и изобретение транзистора.

Первые открытия в физике полупроводников были сделаны американскими физиками У.Шокли, У.Браттейном и Д.Бардином. Джон Бардин – дважды Нобелевский лауреат. Он получил первую Нобелевскую премию за изобретение транзистора, а вторую – за теорию сверхпроводимости. Можно говорить о том, что после 1955 г. США стали постиндустриальным или информационным обществом.

Лазер является следующим крупнейшим изобретением XX века. Сегодня лазеры получили самое разнообразное применение – технологическое, медицинское, военное. Одно из самых важных применений в информационной сфере родилось из создания так называемых лазеров на основе полупроводниковых гетероструктур. Именно такой лазер - монокристалл, состоящий из различных элементов, стал сердцем волоконно-оптической связи. Сегодня Земной шар опоясан почти 70 миллионами оптических волокон для различных видов связи.

Считается, что квантовая физика твердого тела является сегодня основой дальнейшего научно-технического прогресса. Одними из самых современных приборов на основе квантово-размерных структур (наноструктур), являются лазеры и транзисторы на квантовых точках.

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

Get real

You are planning to give a talk at the students' English language conference.

The conference is devoted to "Cutting Edge Research in the 21st Century Physics".

Make use of the *Study help* box when planning to give a talk at the conference.

Study help ***Planning a presentation***

While planning your presentation make use of the following questions:

- What is the purpose of the presentation?
- What are the main points of the presentation?
- How do I make it interesting for my audience?
- What kind of supporting material do I need to illustrate the main points?
- How can the use of visuals help me?
- How can I handle questions?

Conference "Physics of the 21st Century"

1) Choose the field of physics you are most interested in and search the Internet and/or popular science magazines to find out more about the cutting edge research in this field.

2) Make a PowerPoint presentation about it.
Use the questions below to guide you:

- ✓ What is being investigated?
- ✓ Which field of physics does it refer to?
- ✓ Is it theoretical or applied research?
- ✓ Who is doing the research?
- ✓ What are the purpose and novelty of the research?

In the Realm of Science

1. **Here are some idiomatic phrases that come from science and technology.**
   Give their Russian equivalents.

✓ **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

2. 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

Progress Monitoring

In this unit you have worked on the vocabulary on the topic: "Advances of 20th - century physics".

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

1. the basis for further scientific and technological development
2. to attack the frontier of complexity
3. technological/pure or applied science breakthroughs
4. to set a new scale for research
5. to be awarded the Nobel Prize
6. to bring valuable spinoffs
7. to be a milestone in physics
8. to be widely applied in medicine, etc
9. substances with unique properties
10. to hold a conference or educational workshops
11. development of computation and computer techniques
12. physics-based applications
13. mind-boggling frontiers of modern physics
14. to revolutionize research methods
15. novel electronic devices
16. to make an important contribution to sth
17. to bring major advances in science and technology
18. ultra-precision measurements
19. to explore cutting-edge topics
20. the advent of quantum computation

Progress Test

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

a) electron, neutron, atom, proton
b) innovative, valuable, original, cutting-edge
c) huge, enormous, giant, total
d) to uncover, to enable, to open, to untangle
e) to contribute, to cooperate, to collaborate, to assist
f) conference, meeting, symposium, panel discussion

2. Give English equivalents to these Russian word combinations.

a) новаторские приборы и инструменты
b) теория сверхпроводимости
c) волоконно-оптическая связь
d) международное сотрудничество
e) широко применяться
f) теоретическая и прикладная наука
g) технологический прорыв

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

e.g. [pjuə] - pure – теоретический

a) [ʌn'presɪd(ə)ntɪd]
b) ['breɪkθruː]
c) ['faɪbə]
d) ['kwɔntəm]
e) ['sɪlɪndə]
f) [kən'trɪbjuːt]
g) [ɪ'nɔːməs]

4. Rewrite the sentences in the passive. Make any necessary changes.

a) They are studying chemical and biochemical phenomena that occur in natural processes by means of X-ray analysis.
b) It is obvious that technological breakthroughs and innovative instrumentation can spark new discoveries.
c) Powerful telescopes, satellites and probes as well as computer techniques have set a new scale for experimental research in Cosmology.
d) NASA's Marshall Space Flight Centre will hold “Physics for the Third Millennium: III" conference in April next year.
e) Japanese researchers are developing a space elevator, one of the most promising technologies for the would-be outer-space commuters.
f) Physicists have built huge detectors to track the particles as they move outward from a collision.

UNIT 6

AFRAID OF THE NANOWORLD?

"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

Learning Objectives

In this unit you will:

- ✓ learn the vocabulary connected with nanotechnology
- ✓ revisit the Infinitive Construction
- ✓ use key words for efficient reading
- ✓ use various speech patterns to make predictions
- ✓ express opinions in arguments and discussions
- ✓ learn how to write an academic essay

LEAD IN

1. **Read and comment on the quotation:**

> *"Quite simply, the world is about to be rebuilt (and improved) from the atom up. Clothing…food…cars…housing…medicine…the devices we use to communicate and recreate…the quality of the air we breathe…and the water we drink, are all about to undergo profound and fundamental change. And as a result, so will the socio and economic structure of the world. Nanotechnology will shake up just about every business on the planet."*
>
> Josh Wolfe, Editor of Forbes Magazine

2. **Many incredible claims have been made about the future of nanotechnology. We speak about nanoparticles, nanosensors, nanobots, nanotubes and nanomaterials. Work in pairs and discuss these questions:**
   - What exactly does "nano" mean?
   - Why has nanotechnology attracted so much attention in recent years?
   - Do you think that nanotechnology will radically change our life in future? In which way?

3. **Report your ideas to the rest of the class.**

READING

1. **Read the text "How small is small?" and answer the questions.**
   a) What is nanotechnology?
   b) What is the size of nanomaterials?
   c) When did the idea of nanotechnology first appear?
   d) How are the names of Richard Feynman and Eric Drexler connected with the development of nanotechnology?
   e) What possibilities does the nanoscale provide?
   f) What are the application areas for nanotechnology?

2. **The text has eight paragraphs (*A-H*). Identify the key idea in each paragraph and write a paragraph heading**.

Example: (A) – Science on a miniature scale

3. **Compare your headings as a class.**

How Small Is Small?

(A) Science on a miniature scale

Nanotechnology is science and engineering at the scale of atoms and molecules. It is the manipulation and use of materials and devices so tiny that nothing can be built any smaller.

(B) _____

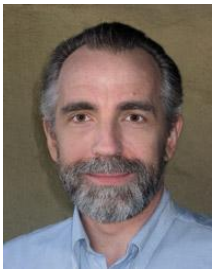
Nanomaterials are typically between 0.1 and 100 nanometers (nm) in size - with 1nm being equivalent to one billionth of a meter. If one nanometer was roughly the width of a pinhead, then one meter on this scale would stretch the entire distance from Washington, DC to Atlanta - around 1000 kilometers. 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.

(C) _____

People have made use of some unusual properties of materials at the nanoscale for centuries. 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.

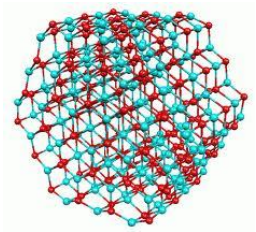
(D) _____

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.

(E) _____



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.

(F)_____

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.

(G)_____

Nanotechnology is also expected to play a major role in environmental protection. Nanoparticles may be used in contaminant neutralization, magnetic techniques, special filtering and cleaning methods, environmental decontamination and energy conservation and in the production of energy efficient devices.

(H)_____

Nanotechnology involves manipulations of matter at extremely small levels and its applications appear to be almost 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.

Focus on language

1. **Read the text again. Find international words and write them down. There are about forty of them. Make sure you can pronounce them correctly in English.**

Example: nanotechnology – нанотехнология/и; molecular - молекулярный

2. **Match the verbs from *A* with the most suitable word(s) from *B*. In case of difficulties look back in the text. Then translate the word combinations into Russian.**

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	j) a scanning tunneling microscope
11) to create	k) the idea
12) to aid in	l) unusual properties
13) to contribute to	m) materials

3. **Here is the sentence from the text. How do you translate it into Russian?**

Nanotechnology is *also* ***expected to play*** *a major role in environmental protection.*

The Infinitive Construction (Complex Subject)

Study the model and the sentences given below. Remember the way the sentences are translated into Russian:

smb/smth + **verb** + **to-infinitive**

Note the typical verbs that are used to form this Infinitive Construction:

A) Passive		***B) Active****	***C) be+adj***
to be thought	to be predicted	to appear	to be likely
to be believed	to be considered	to seem	to be unlikely
to be assumed	to be reported	to prove	to be sure
to be expected	to be said	to happen	to be certain

*These verbs are active in form but passive in their meaning.

Examples:

- ***Nanotechnology*** *<u>is predicted</u>* ***to contribute*** *to new cancer therapies.*

Делаются предположения, что **нанотехнологии будут способствовать** появлению новой терапии онкологических заболеваний.

- ***Nanotechnology applications*** *<u>appear</u>* ***to be*** *limitless.*

Оказывается, что **применения нанотехнологий являются** безграничными.

- ***Nanotechnology*** *<u>is likely</u>* ***to change*** *every sphere of our life in the near future.*

Вероятно, **нанотехнологии изменят** каждую сферу нашей жизни в ближайшем будущем.

4. **Rewrite the sentences (*a-g*) following the Complex Subject model in the box. Make use of the verbs in brackets. Translate the sentences into Russian.**

Example:

Nanotechnology will impact a broad range of fields, from basic science to consumer goods. ***(assume)***
Nanotechnology *<u>is assumed</u>* ***to impact*** *a broad range of fields, from basic science to consumer goods.*

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

LISTENING

1. **Listen to an interview with Ian Pearson, a specialist in nanotechnology, and fill in the chart.**

Field of application for nanotechnology	Possible benefits
✓ …… ✓ …… ✓ ……	✓ …… ✓ …… ✓ ……

2. **Listen again and fill in the gaps in the extracts (a-c).**

a) "… in the future nanotechnology could go far, far further. One day scientists could (1) _____ molecules to create tiny computers or (2) _____ that will fuse with our bodies."
b) "Nanorobots will be programmed to (3) _____ and reconstruct the molecular structure of cancer cells and viruses to make them harmless. There is even a speculation that nanorobots could (4) _____ or reverse the aging process, and life expectancy could (5) _____ significantly."
c) "Besides nanotechnology has also the potential to have a (6) _____ effect on the environment. For instance, airborne nanorobots could be programmed to rebuild the thinning (7) _____ layer. Manufacturing materials using the bottom up method of nanotechnology also creates less (8) _____ than traditional manufacturing process. Cutting down trees, mining coal or drilling for oil may no longer be necessary. Resources could simply be (9) _____ by nanomachines."

SPEAKING

Work in small groups and discuss:

- Which ideas discussed in the interview in the ***Listening*** task do you find most surprising? Why?
- What dangers or risks connected with nanotechnology can you predict?

Make use of the expressions in the boxes.

Functional language Making predictions

I'm certain that…, I doubt that…,
I would imagine that…,
There is no doubt that…,
It's highly unlikely that…,
There's a chance that…,
The chances are that…,

Future time expressions

by the middle of this century
in five years' time
in the near future
in the next few years
within a decade or so
in the distant future
(not) in my lifetime

READING

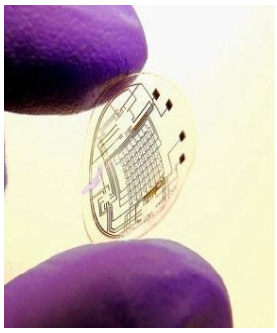
1. **The headline of the text you are going to read is "The Hype and Hope of Nanotechnology". What do you think it is about? Work in groups of three. Write down some predictions. Discuss them as a class.**
2. **Read the text and check your predictions.**

THE HYPE AND HOPE 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.

3. **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?

4. **Explain the highlighted expressions. Use a dictionary or consult your teacher if necessary.**

Summarizing

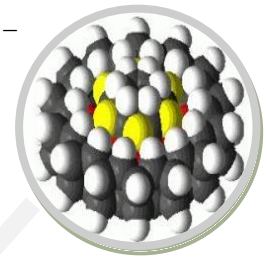
1. **Read the article about the present and future of nanotechnology and highlight the Russian equivalents to the English word combinations (1-14).**

   1) to originate from the Greek "nanos" which means "dwarf"
   2) to study the properties of objects
   3) powder, suspension
   4) to prevent rust/corrosion
   5) to increase useful/effective life
   6) ultrastrong/superstrong materials
   7) carbon nanotubes
   8) to improve performance
   9) safe storage of something
   10) semiconductor devices and microchips
   11) medicine of directional effect
   12) tissue and organ growth
   13) to achieve immortality
   14) new types of engines and fuel cells

Add new vocabulary to your vocabulary notebook. ✍

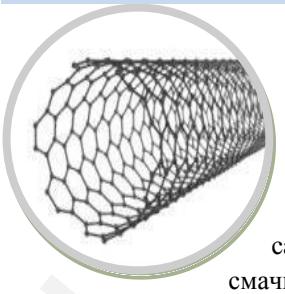
2. **Read the article again and summarize it in English using the word combinations in Task 1 and the phrases for summarizing.**

Что это?



Нано (от греч. nanos – «карлик») – миллиардная доля чего-либо. Область прикладной науки и техники, занимающаяся изучением свойств объектов размером в 10^{-9} метра. Нанотехнологии манипулируют отдельными атомами и молекулами, а также разрабатывают устройства подобных размеров.

Что дают сейчас?



Материалы

Порошки, суспензии. Улучшают работу двигателей, предотвращают ржавчину, помогают материалу самоочищаться или не смачиваться водой.

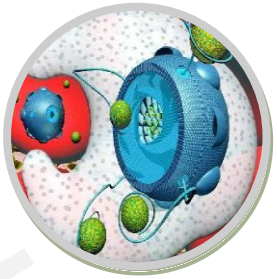
Упаковки. Увеличивают срок годности продукции.

Сверхпрочные материалы из углеродных нанотрубок.

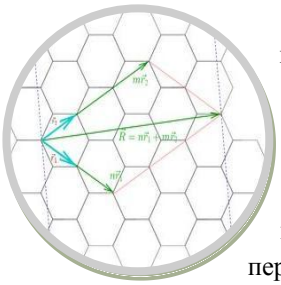
Медицина

Разработка новых лекарств (в том числе от рака) и диагностического оборудования.

Первые нанороботы, способные путешествовать по организму животных.



Энергетика, электроника



Покрытие для солнечных панелей. Увеличивает КПД.

Безопасное хранение водорода с помощью нанотрубок.

Увеличение объемов компьютерной памяти и скорости передачи данных.

Новые полупроводниковые приборы и микросхемы.

Что дадут в будущем?

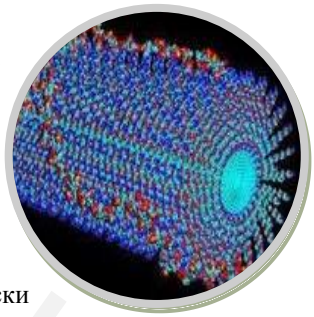
Материалы

Конструирование любых молекул. Создание абсолютно прочных материалов. Появление наноеды – несуществующей в природе пищи для человека и животных.

Медицина

Лекарства направленного действия, проникающие на пораженную ткань или опухоль. Индивидуальные препараты.

Микрохирургия нового уровня, повсеместное использование нанороботов для диагностики и лечения почти всех болезней.



Выращивание тканей и органов. Оживление замороженных ранее людей с целью их лечения, продления жизни. Фактически достижение бессмертия.

Энергетика, электроника

Принципиально новые типы двигателей и топливных элементов.

Сверхминиатюрные электронные устройства

Новые способы записи и хранения информации. Гибкие дисплеи, появление электронной бумаги.

Get real

Search the Internet and/or popular science books and magazines for more information on the potential benefits and possible risks of nanotechnology. Prepare to report your findings to the class.

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.

2. **Present your ideas to your opponents. Make sure you include the introduction, the arguments *'for'* or '*against*' nanotechnology and the conclusion. Try to be as convincing as possible.**

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…

WRITING

Read these statements. Choose one of them and write an essay to express your opinion. Follow the guidelines in the *Study help* box.

- **Nanotechnology will develop regardless of what we do or don't do.**
- **Nanotechnology represents not only wonderful benefits for humanity, but also grave risks.**
- **The anticipated threats and benefits of nanotechnology are exaggerated as they are based on theoretical rather than practical experience.**

Possible introduction:

Nanotechnology is the use of very small particles- measured in the billionths of a metre. At theses sizes, even the simplest, best-known materials can take on surprising new properties....

Study help

An academic essay in English follows the following structure:
Introduction: re-statement of the topic and indication of writer's position
Body of the essay:
Paragraph 1: main ideas
supporting ideas
Paragraph 2: main ideas
supporting ideas
Conclusion: summary of views and re-statement of position

In the Realm of Science

1. **Learn to say the following:**
   - **10^{9}** ten to the power nine
   - **10^{-9}** ten to the power minus nine
2. **Read the prefixes that show various sizes.**

Number	Prefix	Symbol	Number	Prefix	Symbol
10^{1}	deka-	da	10^{-1}	deci-	d
10^{2}	hecto-	h	10^{-2}	centi-	c
10^{3}	kilo-	k	10^{-3}	milli-	m
10^{6}	mega-	M	10^{-6}	micro-	u (greek mu)
10^{9}	giga-	G	10^{-9}	nano-	n
10^{12}	tera-	T	10^{-12}	pico-	p
10^{15}	peta-	P	10^{-15}	femto-	f
10^{18}	exa-	E	10^{-18}	atto-	a
10^{21}	zeta-	Z	10^{-21}	zepto-	z
10^{24}	yotta-	Y	10^{-24}	yocto-	y

Progress Monitoring

In this unit you have worked on the vocabulary on the topic: "Nanotechnology"
Tick (*V*) the points you are confident about and cross (*X*) the ones you need to revise.

1. nanoparticles/nanobots/nanotubes
2. at the scale of atoms/molecules
3. fundamental/unusual properties of materials
4. scanning tunnelling microscope
5. potential/unlimited possibilities for applications
6. to bring about sth
7. self-assembly/artificial implants
8. self-heating/cooling/water-and stain repellent/ wrinkle-free clothes
9. potential hazards of sth
10. to use a bottom up method
11. mass storage devices
12. to move sth into the mainstream
13. bio-compatible/high-performance materials
14. advanced weapons
15. to increase the capabilities of space ships
16. self-replicating nanomachines
17. to sound amazing/unbelievable
18. to monitor sb's body/detect/fix problems
19. to rush quickly into the future
20. to represent wonderful benefits/grave risks

Progress Test

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

a) device, machine, technique, computer
b) chemical, optoelectronic, biomedical, unlimited
c) atom, crystal, molecule, particle
d) potential, microscopic, atomic, molecular
e) scientists, engineers, environmentalists, nanobots
f) risk, threat, conservation, hazard

2. Give English equivalents to these Russian word combinations.

a) происходить от греческого «карлик»
b) производство энергосберегающих устройств
c) разделяться на два противостоящих лагеря
d) потенциальные риски/опасности
e) новые типы двигателей и топливных элементов
f) достигать подъема от чего-либо
g) выходить из под контроля

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

e.g. [ˈmolɪkju:l] – molecule – молекула

a) [daɪ'æmɪtə]
b) [kən'trəʊl]
c) [mə'lekjulə]
d) ['prəusesə]
e) [tek'nɔlədʒɪ]
f) [mə'ʃi:n]
g) ['maɪkrəskəʊp]

4. Identify and underline Infinitive constructions (Complex Subject) in the sentences below. Translate the sentences into Russian.

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

UNIT 7

SCI-FI OR SCI-FACT?

Enjoy the Movies but know the Science!

L. Immoor

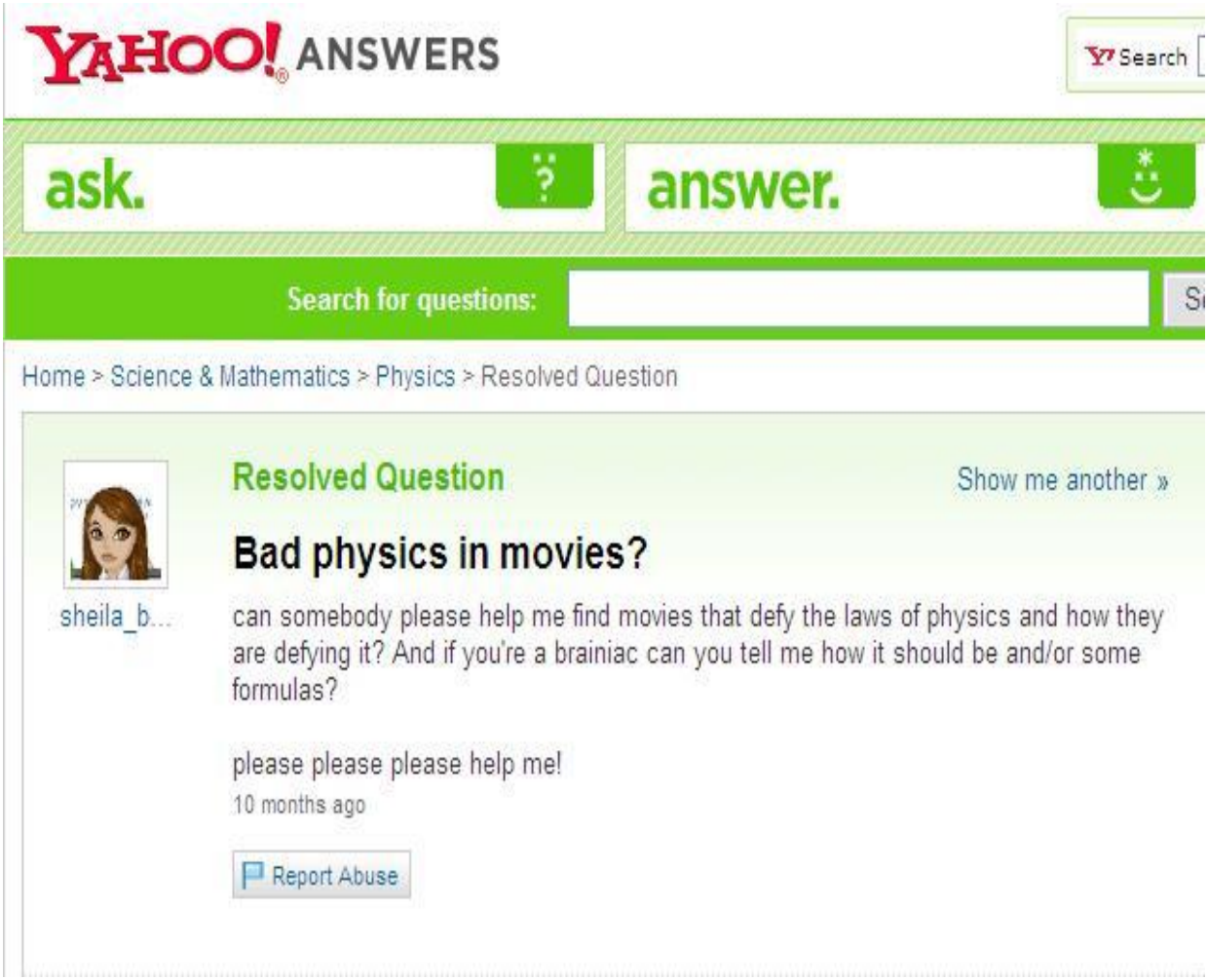
Learning Objectives

In this unit you will:

- ✓ revisit the usage of adverbs
- ✓ use various speech patterns to express opinions
- ✓ revisit the language for speculating, deducing and talking about the future
- ✓ talk about possible future achievements in science and technology
- ✓ conduct a poll
- ✓ organize and develop ideas into a report

LEAD IN

1. **There is a question posted by a high school student on one of the *Yahoo!* websites.**



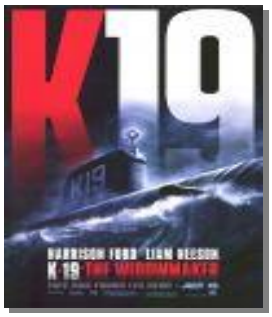
- ✓ Do you ever notice when movie scenes disregard the laws of physics?
- ✓ Do you ever discuss or criticize the movie physics with your peers? Why?/Why not?
- ✓ Can sci-fi films inspire young viewers to follow real careers in science?

2. **Work with a partner.**

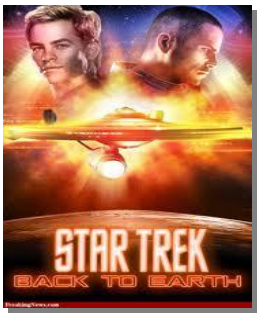
- Make a list of examples of bad movie physics (*e.g. flashing bullets; a car falling from a high place explodes the instant before it hits the ground, etc.*).
- Give reasons why you think such things contradict the laws of physics.

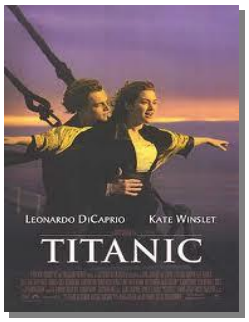
READING

1. **Read the critical excerpts (*A-H*) about the bad physics in movies and match them with the pictures (1-7). There is one extra text.**

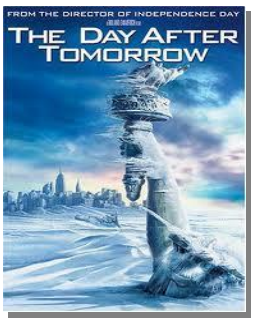
1) 

2) 

3) 

4) 

5) 

6) 

7) 

A) Originally the creators of the movie got it right. In early episodes, when something exploded in outer space, it made no sound. That's because there is no air in outer space to transmit sound.

Yes, an explosion probably would create an expanding cloud of gases which would eventually impact a spaceship in its path. However, in the vacuum of space this expanding cloud of gas would have a very low density. When it hit a ship some distance from the explosion it would probably sound like a gust of wind* blowing against the spacecraft.

Unfortunately, the moviemakers eventually succumbed* to market pressures and began adding sound effects to explosions. To make matters worse, the sounds were portrayed as traveling at the speed of light, since they always arrived simultaneously with the image of the explosions.

*a gust of wind - порыв ветра
*to succumb - поддаваться, уступать

B) Surprisingly, this movie never mentions chaos theory. The idea that dumping massive amounts of CO_2 into the atmosphere can cause global warming is widely accepted but an ice age brought on by global warming seems to defy* common sense.

Yes, the movie does offer some explanation but it might actually make more sense in the context of Chaos theory. Chaos theory has its roots in meteorology and causes one to expect weather paradoxes.

Okay, at least the special effects were reasonably entertaining even though based on badly flawed* science. Certainly, this movie is a fluff* piece aimed at box office take.

*to defy - бросать вызов
*flawed - бракованный; дефектный
*fluff что-л. незначительное, банальное, малоинтересное

C) It is a classic sci-fi thriller, with fairly decent* physics, and even provokes a fair amount of thought (at least for an action film) on the nature of time travel.

The car crashes are not overdone; cars don't ramp and flip over when they shouldn't (like they do in many other movies). And for the most part there were no sparking bullets.

However, there were a few flaws. Time travel can't be taken too lightly. It's a bit of a stretch* when they claim the fields around bio-mass allow for time travel while metallic objects cannot be sent back, but there's no way to say that's definitely impossible.

Overall, this movie is impressive for the originality it displayed in the early '80s, with relatively little impossible physics.

*decent - *здесь* неплохой, сносный
*a bit of a stretch – *здесь* слегка преувеличивают

D) The movie is based on a true story but, as is Hollywood's habit, plays fast and loose with historical facts. The real story is compelling* and chilling* enough that it doesn't need additional Hollywood nonsense.

Unfortunately, the movie seriously alters physics. We're told that the out-of-control reactor is on the verge of* exploding and when it does, it will set off the nuclear warheads on board the submarine and destroy a nearby American Navy vessel. Yes, the fuel in an uncooled nuclear reactor would eventually cause the containment vessel to fail leading to a very nasty thermal explosion. However, the blast would not be a nuclear explosion. The blast most likely would not set off nuclear warheads. Nuclear warheads are very difficult to set off by accident. There would be problems with nuclear contamination but not nuclear explosions.

Such a movie is a serious disservice to all, especially when it deals with important subjects like international relationships and nuclear weapons.

*compelling - захватывающий, интригующий, очень интересный
*chilling - страшный, ужасный
*on the verge of - почти, на грани, вот-вот

E) While not perfect, we must admit that it is one of the biggest physics movies around. Our soaked-to-the-skin hero and heroine also appeared immune to the cold night air as they stood on deck bravely waiting the final moments of sinking. Perhaps they were warmed by the glow of romance. Once in the water, however, things did seem to cool a bit, at least in the thermal sense.

Human stuff aside, the big screen portrayal of the sinking was awesome. It had it all: linear and rotational velocity, acceleration, and inertia with torque* forces, Archimedes principle, and fluid dynamics included on a, well, titanic scale. We resorted* to the right-hand thumb rule* no less than three times in order to determine the direction of rotational vectors: first as the ship's stern rotated upward, then as it rotated downward when it broke off, and finally as it rotated upward again just before sinking - a three right-hand thumb movie, wow!

*torque - *физ.* вращающий момент
*to resort to - прибегать к (чему-л.) , обращаться к (чему-л.)
*thumb rule - эмпирическое правило, "на глазок"

F) It's hard to argue with the physics of a movie like this. Considering the action takes place mostly in a computer simulation, flaws in physics can usually be dismissed as bad programming. For instance, at the beginning of the movie a girl hacker jumps five feet off the ground and pauses in mid air before kicking a policeman just below his neck.

What's more, since the girl was about half of the cop's mass and the collision of her foot with him was largely elastic (it didn't stick to him) she should have bounced* backward to conserve momentum. In addition, we just can't buy the explanation* of why the computer system bothers to maintain not only the simulation but humanity. Supposedly, the computer system needs people as a power source. This makes no sense.

The movie comes dangerously close to implying that the computer energy system is a giant perpetual machine. This is clearly impossible according to the second law of thermodynamics. So, this film definitely fails to meet its potential because it just can't leave the artificial science in the computer simulation along with the artificial intelligence.

G) A nasty gang of insensitive aliens arrive in an intergalactic recreational vehicle (RV) a quarter the mass of the Moon and proceed* to systematically trash Earth. Just having the aliens show up would totally disrupt the natural order. In fact, an object with a quarter of the Moon's mass, parked in geostationary orbit would create a tide*-producing gravity force twenty-five times higher than the one caused by the Moon. This would flood coastal areas and disrupt* geological formations, resulting in earthquakes and volcanic eruptions, not to mention extreme weather changes.

Moreover, these disasters of biblical proportions would only be the beginning. If it took the mother RV an hour to slow down, the energy released by its engines would be about ten times greater than the entire luminosity of the sun. We'd be fried before the aliens even arrived. In the movie, however, we are somehow miraculously spared from these inconveniences.

Once inside the mother RV* the hero connects his Mac to the alien computer. Fortunately, the alien's computer operating system works just fine with the laptop. This proves an important point which Apple enthusiasts have known for years. While the evil empire of Microsoft may dominate the computers of Earth people, more advanced life-forms clearly prefer Macs. ☺

* proceed to - приступать, приняться за (что-л.)
*tide - прилив и отлив (на море, океане);
*to disrupt - разрывать, разрушать

H) The physics in this movie not only lacks simple logic, but it also seems to be not from around here. For instance, we have a force field around an underwater city which keeps water out but which a human who is over 80% water can walk through. In the great battle scene, the bad guys drive up in giant tanks and attempt to blast the good guys who are protected by their force field. This force field is transparent to visible light but nevertheless repels* blasts of visible laser beams. We won't reveal the ending of the fierce* battle scene for those who haven't seen it, but we do have a few nagging* questions. First, why would anyone design an android army which was entirely dependent on receiving signals from a mother ship in outer space? Second, why were none of the good guys smart enough to figure this out and jam the signals?

*to repel - *физ.* отталкивать
*fierce - жестокий
*nagging - ворчливый, сердитый

2. Answer the questions.

a) What is wrong with the sounds of explosions in the outer space?

b) Why chaos theory would be worth mentioning in explaining the dramatic climate change in the film?

c) What would be the most probable consequence of a thermal explosion on board nuclear submarine?

d) What makes the big screen portrayal of the **Titanic** sinking so realistic?

e) Why is it hard to argue with the physics of **Matrix**?

f) Why is it impossible to create a perpetual machine?

g) What natural disaster would be caused by a giant intergalactic recreational vehicle?

h) What is wrong with the force field in **Star Wars**?

i) Which film do you think ***text G*** refers to?

Transformers **Independence Day** **Signs** **War of the Worlds**

3. Work with a partner. Give Russian equivalents to these phrases. Consult a dictionary if necessary.

- to make matters worse (Text A)
- to have roots in sth (Text B)
- to provoke a fair amount of thought (Text C)
- to play fast and loose with historical facts (Text D)
- to be a serious disservice to sb/sth (Text D)
- to fail to meet the potential (Text F)
- a disaster of biblical proportions (Text G)
- to lack simple logic (Text H)

Study help

We remember new words much more easily if we think about them in relation to our own experience and if they have some personal meaning for us.

4. Think of your own context in which you can use these expressions. Write down your own sentences with them. Check them as a class.

5. Match the words in *A* with the nouns in *B* to make collocations used in the texts.

A	B
1) chaos	a) momentum
2) transmit	b) simulation
3) jam/receive	c) theory
4) laser	d) principle
5) artificial	e) machine
6) outer	f) sound
7) geostationary	g) signals
8) nuclear	h) intelligence
9) perpetual	i) beams
10) conserved	j) orbit
11) linear and rotational	k) space
12) Archimedes	l) explosion/contamination
13) computer	m) velocity

Add new vocabulary to your vocabulary notebook. ✍

Discuss

- Why do you think some of the experts and general public widely discuss the problem of bad science in movies on the internet sites?
- Does it make sense to criticize bad physics in movies? Why?/Why not?
- Would you like to make any of the movie special effects a reality?

Focus on language

1. **Read the sentences and study the models in the box.**

   - *Einstein had another **remarkably successful** theory called General Relativity.*
   - *It is a classic sci-fi thriller, with **fairly decent** physics.*
   - *It is impossible for the sound to **arrive simultaneously** with the image of explosion.*
   - *Unfortunately, the movie **seriously alters** physics.*

   Adverb Collocations
   Adverbs often go with certain verbs and adjectives. Look at the examples below:

Verb + Adverb/Adverb + Verb	***Adverb + Adjective/Participle***
to think quickly	completely useless
to speak confidently	unusually fast
to fully/thoroughly investigate	badly/well organized
to strongly suggest/recommend	widely accepted/applied

2. **Look back in the texts, find and write down adverb collocations.**
3. **Complete the sentences with a suitable adverb from the box and translate them into Russian.**

   extremely perfectly remarkably clearly definitely totally highly seriously astonishingly systematically

   a) My congratulations! Your project work is done just _____!
   b) The process of flying a spacecraft to a distant target is _____ complex.
   c) This movie _____ alters physics.
   d) I work with a _____ -motivated team of researchers.
   e) This is _____ impossible according to the second law of thermodynamics.
   f) The film _____ fails to meet its potential.
   g) In this movie aliens proceed to _____ trash the Earth.
   h) Just having the aliens show up would _____ disrupt the natural order.
   i) The equipment is in _____ good condition for the experiment.
   j) Pulsars are stars that emit very short bursts of radiation at _____ precise repetition rates.

4. **Make up 3-5 sentences of your own with the adverb collocations in the *grammar* box.**

SPEAKING

Work in small groups. Make a list of 3-4 action, adventure or sci-fi movies you have recently seen.

✓ How would you rate them?

GP – good physics in general

PGP – pretty good physics

XP – obviously physics from an unknown universe

NR – unrated (when a movie is obviously a parody, fantasy, cartoon or is clearly based on a comic book it can't be rated but may still have some interesting physics worth discussing)

✓ Are any laws of physics neglected in these films? Which ones?

Sum up what exactly is wrong.

Discuss as a class.

Make use of the *Functional language* box to express your opinion.

Functional language ***Expressing opinions***

I think/feel/believe (that) …,
In my opinion/view …,
It seems to me that …,
I completely/fully agree with/ that …,
I am totally against/I strongly disapprove of/I completely disagree with (the idea/suggestion/statement that) …,
The thing that annoys me most is …,
What I (dis)like about … is (that) …,
I am entirely in favour of …

WRITING

Write about an action, adventure or sci-fi film you have recently seen. Follow the guidelines.

- When and where did you see it?
- Why did you choose this film?
- What type of film was it?
- How would you rate the physics of the film? Why?
- Did you enjoy the film more or less than you expected?
- Would you recommend this film?

LISTENING

1. **You are going to hear an interview with Dr. Marc Rayman, a scientist at the Jet Propulsion Laboratory, speaking about the possibility of time travel. Before you listen answer the questions.**

   - Why is time thought to be a very mysterious thing?
   - Have you ever heard of wormholes? What are they?
   - Will it ever be possible to travel in time? Why?/Why not?
   - How would you imagine a Time Machine? How could it operate?

2. **Check if you know the meaning of these words and phrases. Give their equivalents in Russian. Use a dictionary if necessary.**

▪ to be mind-boggling	▪ to prevent sb from doing sth
▪ empty space	▪ to consume energy
▪ space and time distortions	▪ to account for sth
▪ to be stationary	▪ to take sth into account
▪ a valid theory	▪ a distant target
▪ a shortcut through space-time	▪ to make sth worthwhile

3. **Listen to the talk. Does the speaker answer any of the questions in Task 1?**

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

   a) Albert Einstein's theory of Special Relativity doesn't allow for time travel. ( )
   b) There is no speed limit for objects travelling through space-time. ( )
   c) When somebody moves through space-time with speed close to that of light, time goes slower for them than for the people who stay on Earth. ( )
   d) Einstein's theory of General Relativity postulates that time passes much faster for objects in gravitational fields. ( )
   e) Intense gravitation of Black Holes and other exotic objects leads to space and time distortions. ( )
   f) One can never travel to a time before the time machine was constructed. ( )
   g) Dr. Marc Rayman thinks it is hardly possible to travel fast into the future. ( )
   h) It is vitally important to take into account time distortions for precise spacecraft navigation throughout the solar system. ( )

5. **Sum up the information you have learned from the *Listening* exercise to give a detailed answer to the question: "Is time travel possible?"**

Discuss

- Does Dr. Marc Rayman sound convincing about the possibility of time travel?
- What sci-fi films about time travel have you seen? What kinds of *'time machines'* are used in these films?
- Which would you prefer - traveling to the past or visiting the future? Why?
- If you had a chance, what things would you definitely change in your past/your country's past/the planet's past?

READING

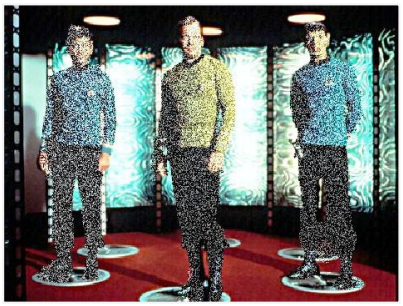
1. **Answer the questions.**

   - What is teleportation?
   - Which field of physics studies the possibility of teleportation?

2. **Read the text to find out more about the advances in the field of quantum teleportation.**

TELEPORTATION: MOVING CLOSER TO REALITY?

Ever since the wheel was invented more than 5,000 years ago, people have been inventing new ways to travel faster from one point to another. The chariot, bicycle, automobile, airplane and rocket have all been invented to decrease the amount of time we spend getting to our desired destinations. But all these forms of transportation share the same flaw: they require us to cross a physical distance, which can take from minutes to many hours depending on the starting and ending points. If time and space could be eliminated from travel - we could be transported to any location instantly, without actually crossing a physical distance.



Many of us were introduced to the idea of teleportation, and other futuristic technologies, by the Star Trek television series (1966-1969). Viewers watched in amazement as Captain Kirk, Dr. McCoy and others beamed down to the planets they encountered on their journeys through the universe.

In fact, to teleport someone, you would have to know the precise location of every atom in a living body, which would probably violate the Heisenberg Uncertainty Principle (which states that you cannot know both the exact velocity and the position of an electron at the same time).

It was not until 1993, that the idea of teleportation moved out of the realm of science fiction and into the world of theoretical possibility. Scientists at IBM, led by Charles Bennett, showed that it was physically possible to teleport objects, at least at the atomic level. More precisely, they showed it could be possible to teleport all the information contained within a particle.

The first historic demonstration of quantum teleportation in which photons (the basic units of light which sometimes act like particles and sometimes like waves) were teleported occurred in 1997 at the University of Innsbruck. This was followed the next year by experimenters at Caltech who did an even more precise experiment involving teleporting photons. In order to teleport a photon without violating the Heisenberg Principle, the Caltech physicists used a phenomenon known as entanglement. In entanglement, at least three photons are needed to achieve quantum teleportation. The researchers created two entangled light beams - streams of photons. They used these two entangled beams to carry information about the quantum state of a third beam. The first two beams were destroyed in the process, but the third successfully transmitted its properties over a distance of about a yard.

In 2004 physicists at the University of Vienna were able to teleport particles of light over a distance of 600 meters beneath the River Danube, using a fiber-optic cable, setting a new record. However, it was more significant, when later that year, quantum teleportation was demonstrated not with photons of light, but with actual atoms, bringing us a step closer to a more realistic teleportation device.

In these teleportation experiments physicists start with two atoms, **A** and **C**. Then they introduce a third atom, **B**, which starts out being entangled with **C**, so **B** and **C** are coherent. Now atom **A** comes in contact with atom **B**. **A** scans **B**, so that the information content of atom **A** is transferred to atom **B**. **A** and **B** become entangled in the process. But since **B** and **C** were originally entangled, the information within **A** has now been transferred to atom **C**. In conclusion, atom **A** has now been teleported into atom **C**, that is, the information content of **A** is now identical to that of **C**. Notice that the information within atom **A** has been destroyed. It means that the information content of atom **A** (e.g. its spin and polarization) has been transferred to another atom, **C**. In other words, when Captain Kirk beams down to an alien planet, an analysis of his atomic structure is passed through the transporter room to his desired location, where a replica of Kirk is created and the original is destroyed.

In 2006 yet another spectacular advance was made, this time involving a macroscopic object. Physicists at the Niels Bohr Institute in Copenhagen and the Max Planck Institute in Germany were able to entangle a light beam with a gas of cesium atoms, a feat involving trillions upon trillions of atoms. Then they encoded information contained inside laser pulses and were able to teleport this information to the cesium atoms over a distance of about half a yard. For the first time quantum teleportation was achieved between light-the carrier of information and atoms, in other words, between light and matter.

Progress in teleportation was rapidly accelerating. In 2007 Australian physicists proposed a teleportation method that did not require entanglement. They successfully teleported a beam of about 5000 particles.
In their approach, researchers took a beam of rubidium atoms, converted all its information into a beam of light, sent this beam of light across a fiber-optic cable, and then reconstructed the original beam of atoms in a distant location. This method opened up entirely new ways to teleport increasingly large objects.

In 2011 another major goal was achieved by researchers in Australia and Japan who successfully teleported light waves. The information, in the form of light, was manipulated in such a way that it existed in two states at the same time, and it was destroyed in one spot and recreated in another. Like Schrödinger's cat, teleported light is both dead and alive. This new quantum teleportation breakthrough is considered to be a major step toward building safe and effective quantum computers which may one day replace the familiar digital computer sitting on our desks. Moreover, we might also have the ability to advance technology of all kinds in untold ways via quantum computers. It would be an entirely new way of harnessing nature.

Given the progress we have made, when might we be able to teleport ourselves? Physicists hope to teleport complex molecules or even a virus in the coming years. There is nothing in principle to prevent teleporting an actual person, just as in the science fiction movies, but the technical problems facing such a feat are truly staggering. In fact, it will likely take many centuries, or longer, before everyday objects could be teleported - if it's possible at all.

Looking ahead, one day, one of your descendents could finish up a work day at a space office above some far away planet in a galaxy many light years from Earth, tell his or her wristwatch that it's time to beam home for dinner on planet X and sit down at the dinner table as soon as the words leave his mouth.

*Caltech - The California Institute of Technology

3. Build a time line of the stages in teleportation research.

4. Answer the questions.

a) Why have people always needed to invent new means of transport?
b) What is the main limitation of the existing means of transportation? How could teleportation help to overcome it?
c) What does the Heisenberg Uncertainty Principle state?
d) When did scientists first suggest the possibility of teleportation?
e) How did the Caltech physicists manage to overcome the Heisenberg Uncertainty Principle?
f) What happens to the original object which is being teleported?
g) Why was the experiment performed at the Neils Bohr Institute so significant?
h) Will teleportation always require a phenomenon known as entanglement?
i) What promise does quantum teleportation hold for future computers?
j) Will human teleportation be possible one day?

SPEAKING

Work in small groups. Look at the list of most common Sci-Fi Visions of the Future. Choose 3-5 of them that you think will or will never happen/be developed in the future. Give reasons. Report your ideas to the rest of the class. Make sure you use the language of predictions and deductions in the *Functional language* box.

- Teleportation
- Time travel
- Flying cars
- People merging with computers
- Quantum computer
- Space elevator
- Colonizing planets beyond solar system
- Turning Mars into a habitable planet
- Materials for making you invisible
- Artificial Intelligence reaches human levels
- Nanobots to repair and heal people
- Cryogenic preservation of living people

Functional language ***Speculating, deducing and talking about the future***

- The modal verbs *must, may/may not, might/might not, can/can't, could/couldn't* are used for drawing conclusions and making deductions or expressing the degree of likelihood.

Modal auxiliary + Infinitive	**Other phrases**
It must be …	It is definitely …
It may (not) be …/It might (not) be …	It is (highly) probably …
It can't be …/It could be …	May be it is …/Perhaps it's
**It must be* means "*I'm sure it is".*	I think it's …/I expect …
**It can't be* means "*I'm sure it isn't*"	It's improbable/doubtful/questionable

- Both ***be going to*** and ***will*** are used for predictions.

Will for a prediction that can be based more on an opinion than a fact.

e.g. I don't think researchers will make quantum teleportation possible.

Be going to expresses prediction when it is based on a present fact. There is evidence that something is certain to happen.

e.g. By means of LHC (The Large Hadron Collider) scientists are going to reveal the mysteries of the universe.

Project Work

Conduct a Poll

1. **Poll seven to ten people (your fellow students, faculty professors and researchers) to find their answers to these questions:**
   - Are you optimistic or pessimistic about the development of quantum teleportation? Why?/ Why not?
   - Could you name three futuristic technologies that are most likely to become a reality?
   - Which futuristic technology would you like to be implemented in the near future? Why?
2. **Keep a record of the responses and any interesting comments from the interviewees.**

WRITING

Process and summarize the responses in a one-page report. Make sure to include any interesting comments made by your respondents.

Functional language ***Presenting another point of view***

Some of the people think that …
Each of the interviewees believes that …
Most of the people agree/disagree that …
Hardly anybody/Nobody feels that …
According to the majority of people …
Two of ten interviewees say …
50% of people point out that…
Very few people/All the people claim that … etc.

Summarizing

1. **Read the text «Каковы задачи научно-фантастической литературы?» and highlight the Russian equivalents to the English word combinations (1-10).**

1) huge technical capabilities
2) the amount of accumulated scientific experience
3) breadth of scientific research
4) to attract attention to not yet explored opportunities
5) to keep pace with state-of-the-art/cutting-edge science and technology
6) to compete with science in explaining and mastering the laws of nature and society
7) the use of scientific achievements
8) transformation of nature and society
9) social and psychological effectiveness of science in people's lives and minds
10) to be the essence of the present day science fiction

Add new vocabulary to your vocabulary notebook. ✍

Каковы задачи научно-фантастической литературы?

Благодаря гигантскому опыту и колоссальным техническим возможностям наука поднялась на новую, качественно иную ступень. Это, в свою очередь, отражается в повышении интереса к научно-фантастическому жанру литературы.

Однако далеко не все ученые и писатели представляют себе весь объем накопленного человечеством научного опыта, всю широту научных исследований и скорость их нарастания!

В самом деле, лишь малая часть уже известных фактов, явлений природы разрабатывается в научных исследованиях. Гораздо большая их часть представляет собой возможность для самых заманчивых взлетов науки. Привлечение внимания к этим и еще не исследованным возможностям - одна из наиболее серьезных задач научно-фантастической литературы.

Познания писателя должны быть на уровне переднего края современной науки. Иными словами, это достижимо тогда, когда сам писатель является ученым. Вот почему научная фантастика и фантастика вообще не может состязаться с наукой в объяснении и овладении законами природы и общества.

Мечта об использовании научных достижений для преобразования природы, общества и самого человека составляет сущность настоящей научной фантастики. Не популяризация, а социально-психологическая действенность науки в жизни и психике людей – вот сущность научной фантастики настоящего времени.

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

In the Realm of Science

Look at the list of some words widely used in sci-fi stories and films. Which of them are familiar to you? Give their Russian equivalents.

astrogate	-	to navigate in space
chrononaut	-	a time-traveller
hyperspace	-	a fictional plot device. It is typically described as an alternate region of subspace co-existing with our own universe which may be entered using an energy field or other device. Travel in hyperspace is frequently depicted as faster-than-light travel in normal space
grey goo	-	a hypothetical end-of-the-world scenario involving molecular nanotechnology in which out-of-control self-replicating robots consume all matter on Earth while building more of themselves
kiloyear	-	one thousand years

light sail	-	a spacecraft propulsion system using a vast reflective sail to harness the radiation pressure of light
mass-driver	-	an electromagnetically driven launching system, proposed as a method of propelling objects into space or over long distances
megayear	-	a million years
mindfood	-	a substance taken as food or drink containing chemicals which increase one's mental ability
needler	-	a weapon that produces a very narrow beam of energy
pocket universe	-	a universe or reality completely separate from ours which is much smaller, may have different natural laws, and may be artificially created
stellar engines	-	a class of hypothetical megastructures which use a star's radiation to create usable energy

Progress Monitoring

In this unit you have worked on the vocabulary on the topic: "Real science and science fiction".
Tick (*V*) the points you are confident about and cross (*X*) the ones you need to revise.

1. movie special effects
2. artificial intelligence
3. to move out of the realm of science fiction
4. to violate a principle/theory
5. to disregard/contradict the laws of physics
6. to create a perpetual machine
7. futuristic technologies
8. transformation of nature & society
9. a phenomenon of entanglement
10. to make a spectacular advance in sth
11. huge technical capabilities
12. to make sth worthwhile
13. quantum teleportation
14. to provoke a fair amount of thought
15. to colonize planets beyond solar system
16. to travel through space-time/a wormhole
17. to merge with computers
18. to prevent sb from doing sth
19. to hold promise for quantum computing
20. the world of theoretical possibility

Progress Test

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

   a) film, portrayal, movie, picture
   b) spacecraft, ship, automobile, navigation
   c) simultaneously, rapidly, instantly, immediately

d) certainly, definitely, surely, remarkably
e) velocity, acceleration, distortion, inertia
f) to pinpoint, to mean, to imply, to suggest

2. Give English equivalents to these Russian word combinations.

a) путешествие во времени
b) искажения пространства и времени
c) технологии будущего
d) пренебрегать законам физики
e) быть на уровне переднего края современной науки
f) огромные технические возможности
g) область научной фантастики

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

e.g. [ɪk'spləuʒ(ə)n] – explosion – взрыв

a) ['pærədɔks]
b) [ˌsɪmjə'leɪʃ(ə)n]
c) [dɪ'stɔːʃ(ə)n]
d) ['wɜːmhəʊl]
e) [kənˌfɪgju'reɪʃ(ə)n]
f) ['replɪkə]
g) [ˌɑːtɪ'fɪʃ(ə)l]

4. Complete the sentences with the correct adverb.

successfully vitally actually simultaneously instantly hardly

a) It is _____ important to take into account time distortions for precise spacecraft navigation throughout the solar system.
b) Rapid time travel into the future is _____ possible because it will require extraordinary amount of energy.
c) With teleportation technology we could be transported to any location _____.
d) People have always wanted to travel without _____ crossing the physical distance.
e) In 1998 physicists at Caltech _____ teleported a photon.
f) This principle states that you cannot _____ know the location and the speed of a particle.

UNIT 8

PHYSICS+OTHER SCIENCES

"The future of research is interdisciplinary, and it will quickly take us into areas that today we cannot even foresee..."

Michael Tanner

Learning Objectives

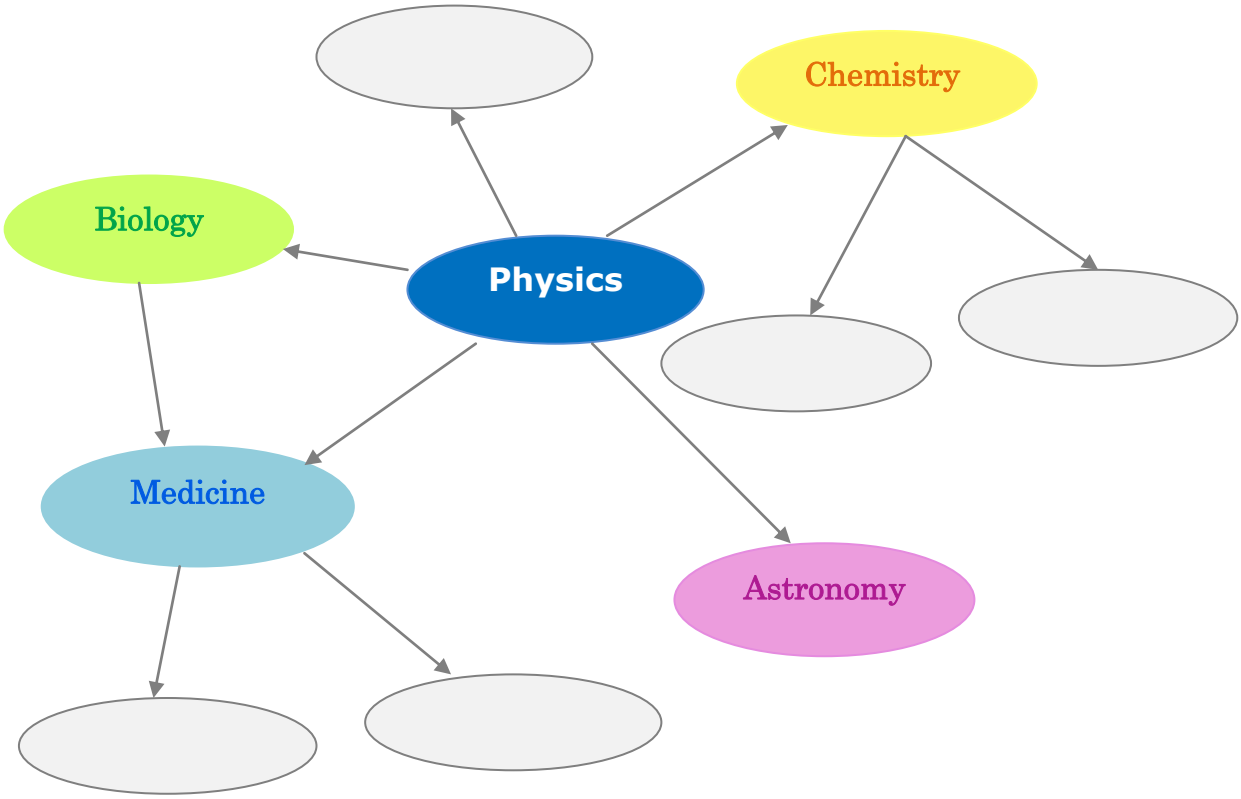
In this unit you will:

- ✓ learn new terms and general science words
- ✓ learn some idioms
- ✓ revisit different ways of expressing purpose
- ✓ use key words for efficient reading
- ✓ make a presentation on some interdisciplinary research in physics
- ✓ write a prospectus for an interdisciplinary department at your faculty

LEAD IN

1. **Work in groups. Read the definition of 'Physics' and think how it is related to other sciences. Fill in the diagram and comment on how physics contributes to other fields of knowledge.**

Physics ['fɪzɪks] n – the science concerned with the study of matter and natural forces such as light, heat, movement, etc.



2. **Are there any interdisciplinary departments (e.g. biophysics …) at your faculty/university? What are they?**

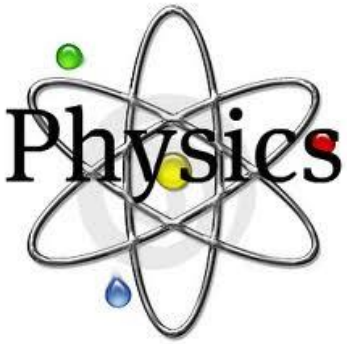
3. **Would you like to specialize in any of these departments? Which one? Why?**

4. **Why is scientists' interest in interdisciplinary research increasingly growing worldwide? Is it true for your faculty?**

READING

1. Match the headings (A-J) to the texts (1-9). There is one extra heading that you don't need to use.

A. Fields in Medical Physics Education
B. Photonic Technology Applied in Medicine
C. Study of Our Planet's Properties
D. Radio Nuclides Curing Diseases
E. Physics Laws 'Rule' in Other Sciences
F. Science Which Works Wonders
G. Great Mission in Solving Global Problems
H. Advances in Physics Leading to Breakthroughs in Medicine
I. These Two Are Always Together
J. Disciplines of Physics in the Study of the Universe



1) One trend in all fields of science over the past century has been to explore ways in which the five basic sciences (physics, chemistry, astronomy, biology, and earth sciences) are related to each other. This has led to another group of specialized sciences in which the laws of physics are used to interpret phenomena in other fields such as astrophysics, physical chemistry and chemical physics, geophysics, and biophysics.

2) Photonics is the technology of generating and harnessing light and other forms of radiant energy. Biophotonics uses photonic techniques across a range of biology based applications, including the therapeutic and diagnostic use of lasers in medicine and biomedical instrumentation.

3) When people think of the impact of science on medicine, they think of biology, they think of chemistry, they may even think of ecology. But they rarely think of physics.
Yet advances in fundamental physics have been responsible for many of the most important breakthroughs in medical science over the past half century. Think of magnetic resonance imaging, laser surgery, even chemotherapy. All of them have relied on dramatic breakthroughs in our knowledge of physics. Indeed medical physicists are responsible for the design and development of most high-tech equipment used for the diagnosis and treatment of a broad range of diseases, including cancer and cardiovascular and neurological disorders.

4) Atmospheric scientists study the Earth's air pressure, temperature, humidity, and wind velocity, and they apply physical and mathematical relationships to make short-range and long-range weather forecasts.
Physical meteorologists, for example, study the atmosphere's chemical and physical properties; the transmission of light, sound, and radio waves; and the transfer of energy in the atmosphere. They also study factors affecting the formation of clouds, rain, and snow; the dispersal of air pollutants over urban areas; and other weather phenomena, such as the mechanics of severe storms.

5) ICTP (International Centre for Theoretical Physics) recognized the relationship between physics and cutting-edge medical research and clinical applications several decades ago when it organized its first College of Medical Physics in 1983. Currently ICTP provides research and training for:

- *Diagnostic radiological physics* focusing on the use of x-rays, ultrasound, radiofrequency radiation and magnetic fields.
- *Radiotherapy physics* focusing on x-rays, gamma rays, electron particle beams and neutrons.
- *Nuclear medicine physics* focusing on the therapeutic and diagnostic applications of radio nuclides.
- *Medical health physics* focusing on x-rays, electron and other charged particle beams, and radio nuclides.

6) Astrophysics is the application of the theories and methods of physics to the study of stellar structure, stellar evolution, the origin of the solar system, and related problems of cosmology. Astrophysics is a broad subject, so astrophysicists typically apply many disciplines of physics, including mechanics, electromagnetism, statistical mechanics, thermodynamics, quantum mechanics, relativity, nuclear and particle physics, and atomic and molecular physics.

7) Only science, with physics as its foundation, can solve many of the serious crises facing our society, such as global warming, overpopulation, waning energy and other natural resources, and the poisoning of our planet. Our leaders need to consult scientists in their decision making.

8) A very typical definition of mathematical physics is the one given by the Journal of Mathematical Physics: "the application of mathematics to problems in physics and the development of mathematical methods suitable for such applications and for the formulation of physical theories."

This definition does, however, not cover the situation where results from physics are used to help prove facts in abstract mathematics which themselves have nothing particular to do with physics. This phenomenon has become increasingly important, with developments from string theory research breaking new ground in mathematics.

Eric Zaslow, professor of mathematics of North Western University, coined the phrase **physmatics** to describe these developments, although other people would consider them as part of mathematical physics proper.

9) To gain perspective into how much physics has contributed to our life, consider the following miracles from physicists: alternating current, hydroelectric power, electric motors, radio, microwave ovens, satellites, radar, modern rocketry, the solution of the DNA structure, nuclear magnetic resonance, magnetic resonance imaging, X-rays, lasers, transistors, light-emitting diodes, oscilloscopes, television, holography, and the World Wide Web (originally developed for high-energy physicists), among many others.

2. Make the right choice (*a, b, c* or *d*) to answer the questions and complete the sentences.

1) Which of the following sciences is not an interdisciplinary one?

a) medical physics
b) nuclear physics
c) mathematical physics
d) chemical physics

2) Photonics is the technology of generating and harnessing different forms of radiant energy which is widely used in

a) laser surgery
b) magnetic resonance imaging
c) microwave equipment
d) transistors

3) Which is not true? Physical meteorologists study

a) the transfer of energy in the atmosphere.
b) the atmosphere's chemical and physical properties.
c) decreasing energy and other natural resources.
d) the formation of clouds, rain and snow.

Study help

Answering multiple-choice questions

- Read the text(s) quickly to get the general idea of what it/they is/are about.
- Look at the first part of the question and underline the key words.
- Don't read options **a-d** yet. Find the part of the text the question refers to.
- Go through the choices and underline the key words.
- Choose the answer that fits best.
- Keep in mind that the information may be rephrased.
- Check your answer against the text.

4) Eric Zaslow coined the phrase physmatics …

a) as a synonym to mathematical physics.
b) to describe the application of mathematics to problems in physics.
c) to describe developments in string theory.
d) to describe the field of abstract mathematics which uses results of physics for proving some facts.

5) Which of the statements is false? Diagnostic radiological physics focuses on the use of ……. for medical purposes.

a) magnetic fields
b) ultrasound
c) x-rays
d) thermodynamics

Focus on language

1. **Study the words in the box and classify them under the headings (1-3):**

   1) ***Disciplinary science***: physics
   2) ***Interdisciplinary science:*** astrophysics
   3) ***Disciplines of physics***: electromagnetism

physical meteorology	biophysics	chemistry
ecology	mathematics	particle physics
photonics	thermodynamics	mathematical physics
physical chemistry	quantum mechanics	astronomy
statistical mechanics	medicine	chemical physics

2. **Look back in the texts (1-9) in *Reading* and pick up more words to add to the lists under each heading (1-3) in Task 1. Look them up in a dictionary for pronunciation and meaning.**

Add new vocabulary to your vocabulary notebook. ✍

Get real

Search the Internet and/or popular science magazines to find out more about current interdisciplinary research projects involving physics in your country or worldwide. Choose the one you find most interesting and prepare a Power Point presentation about it. Use these questions as the guidelines:

- ✓ **What is being investigated?**
- ✓ **Who is doing the research?**
- ✓ **How long has it been under way?**
- ✓ **What are the purpose and novelty of the research?**

SPEAKING

Make your presentation in class and involve the rest of the group into discussion by encouraging them to ask questions.

Functional language ***Dealing with questions***

Could you repeat the question?/Well, the question is "…". Is that right?
I'll be dealing with that a little later on, so if you don't mind I'll answer this question then.
Does that answer your question?
I'm afraid I don't know the answer to your question. Perhaps someone here can help us out?

Focus on language

1. Read the sentences and translate them into Russian. Pay attention to the words in bold.

- *The laws of physics are used **to** interpret phenomena in other fields.*
- *Medical physicists are responsible for the design and development of high-tech equipment used **for** the diagnosis and treatment of a broad range of diseases.*
- *Consider the following miracles from physicists **so that** you could gain perspective into how much physics has contributed to our life.*
- *What were your main reasons **for** joining this interdisciplinary project?*
- *ICTP organized its first College of Medical Physics in 1983 **in order to** provide research and training for diagnostic radiological physics, radiotherapy physics, nuclear medicine physics, and medical health physics.*

2. Study the rules in the box and apply them for analyzing the sentences in Task 1 and Task 3.

Expressing purpose with	***to / not to / in order to / in order not to, so that* and *for***
1) to / not to in order to / in order not to	▪ We use **to/not to** and **in order to/ in order not to** plus an infinitive when the main clause and the clause of purpose have the same subject. ▪ **In order to/ in order not to** is more formal than **to/ not to**.
2) so that	▪ We can use **so that** when the main clause and the clause of purpose have the same subject or when the subject in each clause is different. ▪ We often use **so that** with **can, could** or other modal verbs and the main verb. ▪ We use **so that** when the purpose is *negative (* **so that** ... **won't/wouldn't***)*
3) for	▪ We use **for** with a noun or a gerund.

3. Match A with B to make sentences. Translate these sentences into Russian.

Example: In many cases physics is required to understand concepts in other sciences.
Во многих случаях требуется физика для понимания концепций в других науках.

A	**B**
1) In many cases physics is required	a) for understanding how musical instruments work.
2) Attend several classes and seminars in other departments	b) for translating complex verbal information into pictures and finally into mathematical models.
3) Physics is the science of sound and it is required	c) to understand concepts in other sciences.
4) Your lab report should be well-organized, clear and easy to read	d) to provide funding for doctoral students interested in interdisciplinary fields.
5) Physics requires students to use both right and left brain regions	e) so that I could achieve a good balance of research and teaching.
6) They should make employment opportunities more visible	f) in order to model proteins, identify particular things or people from among vast stores of video and images and to better understand the properties of superconductors.
7) Stanford University has recently created Interdisciplinary Graduate Fellowships programme	g) so that you could start socializing with colleagues in other fields.
8) I decided to apply for the position of a university lecturer	h) in order to convey information to the reader rather than puzzle them.
9) New hardware and quantum-computer applications are being developed	i) so that students in interdisciplinary programmes would have no doubts about their professional future.

4. **In this unit you will come across several idioms. Read the definition of the word 'idiom' and match idioms in column *A* with their meaning in column *B*.**

Idiom is a group of words established by usage as having a meaning not deducible from those of the individual words.

e.g. *to reinvent the wheel* = to waste a great deal of time or effort in creating sth that already exists = изобретать велосипед

A	B
1) to break new ground	a) to be available or exist in a particular way
2) to come in a packet	b) decide that they belong to a particular class or category, often without considering all their qualities or characteristics
3) to think out of the box	c) to make use of an opportunity
4) to pigeon-hole someone or something	d) to know the basic facts or principles of that subject, especially as a result of a particular course of training or instruction
5) to take advantage of something	e) to think about sth, how to do sth, in a way that is new, different or shows imagination
6) to follow sb's path/to follow in one's footsteps	f) to do something innovative that is considered an advance or positive benefit
7) to have/maintain grounding in a subject	g) to go in the same direction as somebody

5. **Match the idioms (1-7) in column A with their meaning in Russian (a-g).**

a) мыслить нестандартно, оригинально
b) знать основы предмета
c) навешивать ярлыки/вписывать в определенные рамки
d) сказать новое слово/начать новую страницу/открыть новое поле деятельности
e) идти по чьим-то стопам
f) воспользоваться чем-либо
g) иметь готовое решение

LISTENING

You will hear two people talking about their experience of interdisciplinary studies.

1. **Listen to an interview with Paul Miller and complete the chart.**

a) Name of the interdisciplinary programme (first subject area + second subject area)	
b) Advantages of doing interdisciplinary research	

c) Personal qualities of people who choose interdisciplinary study	
d) Job opportunities	
e) Advice for students who are thinking of enrolling in an interdisciplinary programme	

2. Listen again and fill in the gaps in the interview extracts.

I am pursuing my **1)** _____ dissertation to develop an interdisciplinary graduate program in **2)** _____ and management because I firmly believe that no **3)** _____ is perfect and no real world problem comes in a **4)** _____.
Working at the frontier of two fields rather than only one can be particularly **5)** _____ but it provides the perfect training ground for thinking out of the **6)** _____, developing the ability to make links between seemingly unrelated phenomena.

Besides success in interdisciplinary fields also requires the development of a common scientific **7)** _____. Many of these graduates end up as consultants, contractors, entrepreneurs or writers – places where they don't have to be **8)** _____. But I personally think that enrolment for interdisciplinary programs will increase only if employment **9)** _____ become more visible.

3. Listen to an interview with Sue Stampe and answer the questions.

a) What does Sue think of having training in an interdisciplinary field?
b) What advantages and disadvantages of interdisciplinary studies does she discuss?
c) What conclusion does she come to at the end of the talk?

4. Choose the correct word from the box to fill in the gaps in the interview extracts. There are two extra words in the box that you don't need to use.

supervisors	value	proper	opportunities	boundaries	
limitations	polytechnic	versus	viability	primary	plus

I have tenure* in a **1)** _____ state university but it took me close to ten years to get my first tenure-track job. I would have made different choices had I known that would be the result of working across fields. I have taught in liberal arts colleges that **2)** _____ breadth, but they typically do not provide any **3)** _____ to continue an active research program.
Besides young scholars are often discouraged by their disciplinary **4)** _____ from engaging in interdisciplinary research projects until they have first qualified for and obtained positions in their **5)** _____ field. As a result it is much harder to find **6)** _____ supervision in an interdisciplinary than in a disciplinary area.
The key point to learn from all this is to see your future not as disciplinary **7)** _____ interdisciplinary, but rather as one of disciplinary and interdisciplinary. Maintain your grounding in your sub discipline while branching out across disciplinary **8)** _____. Doing so will not only increase the **9)** _____ of your research career; it will make it much more interesting.

* tenure - бессрочный контракт - If you have tenure in your job, you have the right to keep it until you retire.

5. Listen to the interview again and check if you have completed the sentences correctly.

Discuss

In a small group discuss these issues and share your ideas with the class.

- The first speaker in the listening task says:

  "No discipline is perfect and no real world problem comes in a packet that's why interdisciplinary education and research seem to be inevitable."

  Do you agree with this statement? Give your reasons.
- The second speaker says that it is much harder to find proper supervision in an interdisciplinary field than in a disciplinary area.

  Is it true for your faculty/university?
- Are employment opportunities as good in interdisciplinary areas as in disciplinary fields in your country?
- How do you understand the message of the picture? Comment on it.

READING

Read the text about some advantages of interdisciplinary research.

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

a) Discipline-based research dominated in science for years but nowadays it has lost its mainstream position. ( )

b) Only discipline-based approach results in outstanding advances in science. ( )

c) Nowadays the integration of information, techniques, concepts and theories from several disciplines contributes to better understanding of many challenging problems. ( )

d) The field of 'smart' materials and structures is good evidence of successful collaboration among researchers with backgrounds in different sciences. ( )

e) Interdisciplinary research projects are not popular world-wide because they require huge financial and intellectual resources. ( )

Realizing Benefits from Interdisciplinary Research

For much of the last century the route to success for most scientists involved identifying a subfield within a discipline and then becoming an expert in it. For many scientists this approach still works. Discipline - based research continues to provide the core of our knowledge about the universe and has led to many fundamental breakthroughs in science.

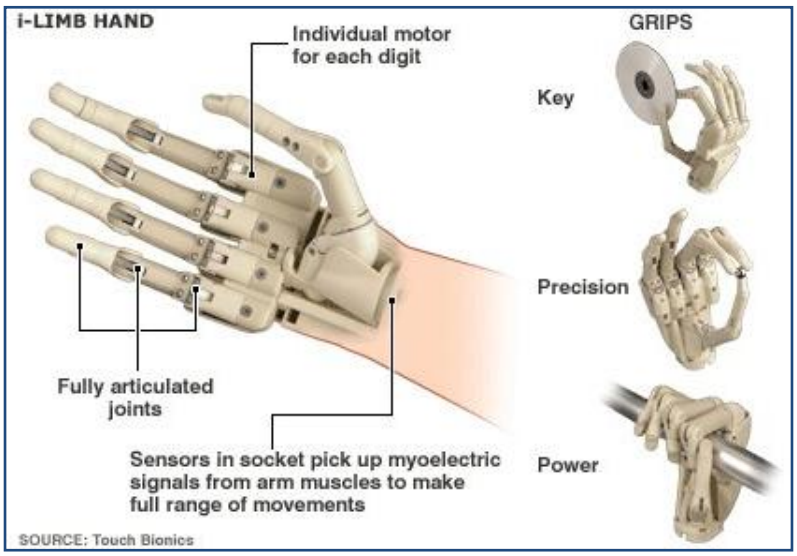
But today, many of the exciting problems in science are too complex to yield only to a discipline - based approach. They require the contributions of scientists from a number of different fields, each bringing their expertise into interdisciplinary research.

Interdisciplinary research is a mode of research by teams or individuals that integrates information, data, techniques, tools, concepts, and theories from two or more disciplines to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or field of research.

The Interdisciplinary Physics is the application of methods and tools of physics to other fields of research, namely biology, chemistry, mathematics, astronomy, geology, economics, sociology and others. An example is the current exploration of string theory by theoretical physicists and mathematicians, in which the questions posed, have given fundamental new insights both to mathematicians and to physicists.

Besides consider the field of "smart" or "intelligent" materials and structures. Here, investigators with backgrounds in physics, chemistry, materials science, biology, mathematics, computers, and engineering cooperate in developing human-made artifacts which sense and respond to their environment by learning, adapting, and repairing themselves.

One great advantage of interdisciplinary science is that it allows people in different fields to work together towards a common objective. Multidisciplinary programs are now under way at many research institutions across the world. At Stanford University alone there are over 22 interdisciplinary research centers, including the recently established BioX program. This $210-million project combines the work of investigators from physics, chemistry, biology, engineering, and medicine in such areas as tissue engineering; single molecule analysis and molecular structure; cognitive and systems neurosciences; imaging from molecules to humans; and biocomputation. With the growth of the Web, many interdisciplinary programs have gone global, making them both cross-cultural and cross-disciplinary.



Summarizing

1. **Read the text "На стыке наук" and highlight the Russian equivalents to the English word combinations (1-11).**

   1) complex and diverse
   2) to study/understand sth in terms of chemistry/physics
   3) high-quality breakthroughs
   4) new sciences are emerging
   5) at the frontier of traditional disciplines
   6) to describe some class of material systems
   7) to be regulated by the laws of physics
   8) to be determined by physical properties of atoms and molecules
   9) to be closely connected with sth
   10) mathematical expressions
   11) a united science of the future

Add new vocabulary to your vocabulary notebook. ✍

На стыке наук

Окружающий нас мир сложен и многогранен. Познать его невозможно с позиций только химии, только физики, только биологии и т.д. Качественные прорывы в решении проблем науки возможны при использовании знаний и методов многих традиционных дисциплин. Так возникают всё новые и новые науки на «стыке» традиционных дисциплин.

Физику иногда называют «фундаментальной наукой», поскольку другие естественные науки (биология, геология, химия и др.) описывают только некоторый класс материальных систем, подчиняющихся законам физики. Например, химия изучает молекулы и образованные из них вещества. Химические же свойства вещества определяются физическими свойствами атомов и молекул, описываемыми в таких разделах физики, как термодинамика, электромагнетизм и квантовая физика.

$$
\begin{aligned}
E_z(x,y,z) &= \frac{z\sigma}{2\epsilon_0}\int_0^{\infty}\frac{R\,dR}{(R^2+z^2)^{\frac{3}{2}}} \\
&= \frac{z\sigma}{2\epsilon_0}\lim_{a\to\infty}\int_0^{a}\frac{R\,dR}{(R^2+z^2)^{\frac{3}{2}}} \\
&= \frac{z\sigma}{2\epsilon_0}\lim_{a\to\infty}\left[-\frac{1}{\sqrt{R^2+z^2}}\right]_0^{a} \\
&= \frac{z\sigma}{2\epsilon_0}\lim_{a\to\infty}\left(\frac{1}{\sqrt{z^2}}-\frac{1}{\sqrt{a^2+z^2}}\right) \\
&= \frac{z\sigma}{2\epsilon_0}\frac{1}{|z|} \\
&= \frac{1}{2\epsilon_0}\sigma\frac{z}{|z|}
\end{aligned}
$$

Физика тесно связана с математикой: математика предоставляет аппарат, с помощью которого физические законы могут быть точно сформулированы. Физические теории почти всегда формулируются в виде математических выражений, причём используются более сложные разделы математики, чем обычно в других науках. И наоборот, развитие многих областей математики стимулировалось потребностями физических теорий.

Один из важных путей взаимодействия наук - взаимообмен методами и приемами исследования, т.е. применение методов одних наук в других.

Многие специалисты считают, что наиболее быстрого роста и важных открытий сейчас следует ожидать как раз на участках "стыка", взаимопроникновения наук и взаимного обогащения их методами и приемами исследования. Этот процесс объединения усилий различных наук для решения важных практических задач получает все большее развитие и способствует формированию «единой науки будущего».

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

Get real

Search the Internet site and/or prospectus of your university. Collect information about several interdisciplinary departments at your faculty/university. Choose the one that is most interesting for you and find information about:

- ✓ **the date of its foundation and the leading researchers**
- ✓ **the major areas of current research, scientific objectives and accomplishments**
- ✓ **the facilities of the department (laboratories, equipment, research schools and traditions, etc.)**

SPEAKING

Present your findings to the class. Follow the guidelines in the *Study help* box.

Study help ***Structure of a presentation***

Introduction (takes 10% of the time)
- Greet the audience and introduce yourself
- Introduce the subject of your presentation, give purpose and main points
- Try to capture interest (by asking a question, giving some quotation or surprising fact)

Main part (takes 80% of the time)
- Have 3 or 4 main points (not more)
- Have signposts and summaries
- Give examples

Conclusion (takes 10% of the time)
- Summarize what you've said
- Thank for attention
- Invite questions

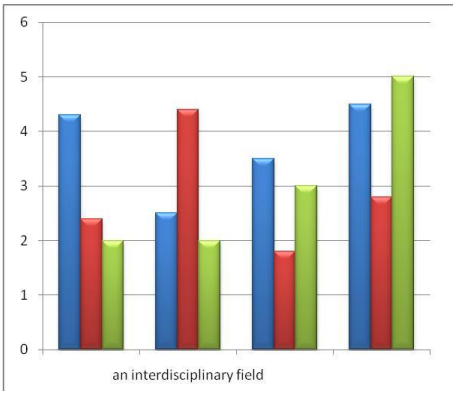
Project Work

Work in groups of four.

1. **Analyse the information about several interdisciplinary departments presented by your fellow students in the Speaking task. Summarize this information as a one-page poster.**

Functional language ***Presenting somebody's opinion***

It surprised us to learn that most students/professors, etc…
The majority of students/people/interviewees think that …
A few students/of my friends have got mixed feelings about…
A number of students/people/interviewees are in favour of …
What we find really astonishing (about) … is …, etc.



2. **Using your group poster conduct a survey to find out which interdisciplinary fields attract your respondents most. (Decide which group you will interview – undergraduate, graduate or postgraduate students or your university teachers). Note down the reasons they give in favour of a particular field and the most interesting comments.**

3. **Analyze your findings and make a bar chart like the one in Task 2 reflecting your survey results. Present this information to the class using the phrases from the *Functional language* box.**

WRITING

Write a group report on the results of your survey. Make use of the Survey Report Form.

Study help ***A survey report***

To write a survey report, follow these steps:

1. Outline the purpose of performing your survey - detail why this survey was developed, who developed this survey and what outcome you expected.
2. Define how the survey was performed - fully describe how you chose your survey takers, questions asked and any other relevant information.
3. Gather your statistical information and organize this into a table, bar chart or graph that can be visually understood by the reader.
4. Write a conclusion that sums up your findings.

A survey: .....

Introduction & Objective

.....
.....

Survey Respondents

.....
.....

Questions & Findings

.....
.....
.....

Conclusions

.....
.....
.....

Visual representation of the statistical data
(a table/bar chart/graph)

Name .....

Date .....

In the Realm of Science

The words in the table can be useful when you speak about interdisciplinary sciences and research. Find their proper equivalents in your language.

Discipline	is an area of knowledge or field of study that is taught and researched at the college or university level.
Disciplinary	refers to knowledge associated with one academic discipline or profession.
Multidisciplinary	refers to knowledge associated with the mixture of academic disciplines in that each discipline retains its methodologies and assumptions without change or development from other disciplines.
Interdisciplinary	refers to new knowledge or one single discipline which resulted from combining two or more academic fields. An interdisciplinary field crosses traditional boundaries between academic disciplines as new needs and professions have emerged.
Transdisciplinary	refers to a research strategy that crosses many disciplinary boundaries to create a holistic approach. It applies to research efforts focused on problems that cross the boundaries of two or more disciplines, such as research on effective information systems for biomedical research (see bioinformatics), and can refer to concepts or methods that were originally developed by one discipline, but are now used by several others, such as ethnography, a field research method originally developed in anthropology but now widely used by other disciplines.
Crossdisciplinary	refers to knowledge that explains aspects of one discipline in terms of another. Common examples of crossdisciplinary approaches are studies of the physics of music or the politics of literature.

Progress Monitoring

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

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

1. to interpret phenomena in other fields of science
2. design and development of high-tech equipment
3. therapeutic and diagnostic use of sth
4. advances in fundamental physics
5. to be responsible for sth
6. to work together towards a common objective
7. to make short-range and long-range forecasts
8. to recognize the relationship between physics and cutting-edge medical research
9. to provide research and training for sth
10. formulation of physical theories
11. to have nothing to do with
12. to break new ground in sth
13. to become increasingly important
14. to come in a packet
15. to prove relevance to practice
16. to think out of the box
17. to give new insights to sb
18. to rely on dramatic breakthroughs in our knowledge of physics
19. to be under way
20. to be at the frontier of several disciplines

Progress Test

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

a) advances, approaches, breakthroughs, insights
b) scientist, supervisor, scholar, researcher
c) ecology, thermodynamics, electromagnetism, relativity
d) cutting-edge, diagnostic, therapeutic, clinical
e) to integrate, to work together, to explore, to cooperate
f) equipment, tool, artefact, device

2. Give English equivalents to these Russian word combinations.

a) терапевтическое и диагностическое использование лазеров
b) становиться всё более важным
c) мыслить оригинально/не думать шаблонами
d) делать краткосрочные и долгосрочные прогнозы
e) работать совместно для общей цели
f) на стыке нескольких дисциплин
g) не иметь никакого отношения к чему-либо/кому-либо

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

e.g. [ˌɪntəˌdɪsɪplɪ'n(ə)rɪ] – interdisciplinary – междисциплинарный

a) ['ʌltrəsaund]
b) [hju:'mɪdətɪ]
c) [vɪ'losɪtɪ]
d) [frʌn'tɪə]
e) ['nju:trɔn]
f) [mæg'netɪk 'rezənəns 'ɪmɪʤɪŋ]
g) ['su:pəvaɪzə]

4. Put two sentences together to make up a sentence of purpose.

Use ***to / in order to / for doing something / so that.***

Example: My friend chose the Physics Department. He had several reasons for that.
*My friend had several reasons **for choosing** the Physics Department.*

a) Two Research Institutes signed the collaboration contract. Now scientists in different fields can work together towards a common objective.
b) I wanted to get the top grade at the exam in Mathematical Physics. I had to work hard.
c) At my department lab classes are widely used. In these classes we practise the application of physical laws and logic to real cases.
d) Before you come to the laboratory, study carefully the laboratory manual. You can plan in advance how to use your time effectively.
e) In the lab follow all written and verbal instructions carefully. In this way you will avoid all possible accidents.
f) Galileo pioneered the use of experimentation. It helped him to validate physical theories.

UNIT 9

CAN PHYSICS HELP SAVE THE WORLD?

"It is easier to denature plutonium than to denature the evil spirit of man."

Albert Einstein

Learning Objectives

In this unit you will:

- ✓ learn the vocabulary connected with global issues
- ✓ practice word formation
- ✓ revisit Relative clauses
- ✓ read for specific information
- ✓ talk about humankind global problems and their solutions
- ✓ write an opinion essay based on a quotation

LEAD IN

1. **Discuss and answer the question: Do we live in a 'wonderful world'? Why? / Why not?" Work in two groups.**

Group 1

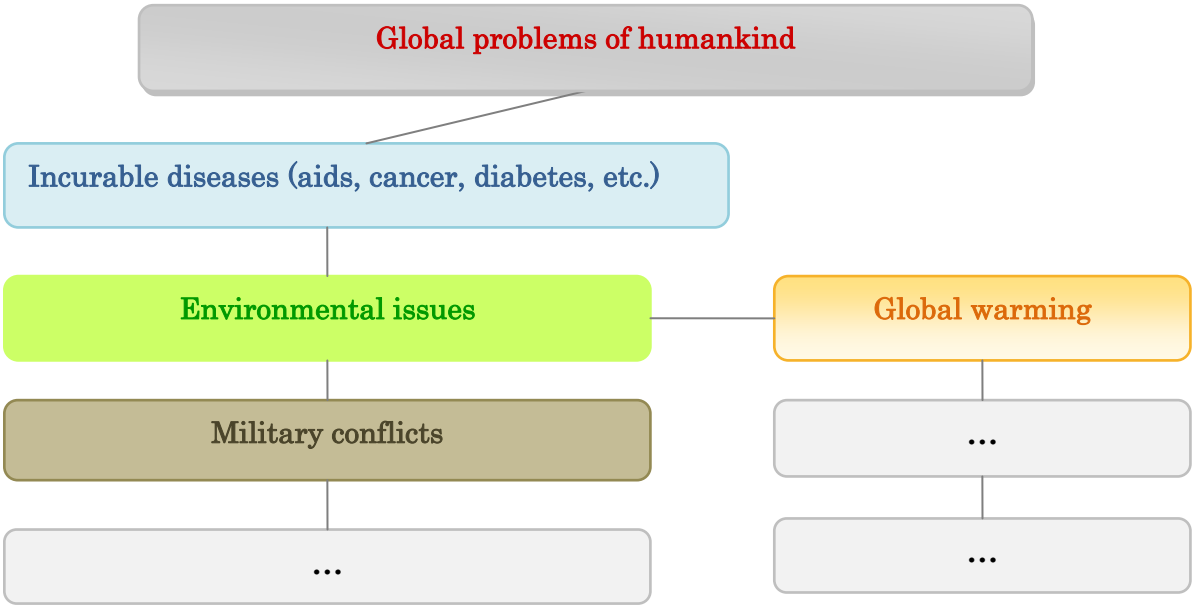
Brainstorm your ideas to answer the question:
What makes our world wonderful?
Make notes of your ideas and be ready to comment on each item on your list in class.

What makes our world wonderful?

- ✓ nature (plants, landscapes, …)
- ✓ …
- ✓ …
- ✓ …

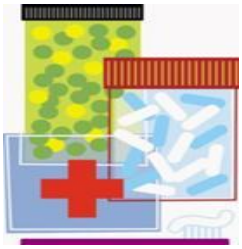
Group 2

Brainstorm your ideas to answer the question:
What problems exist in this 'wonderful world'?
Fill in the diagram below and be ready to comment on it.



READING

1. **Read the text "What threatens our world?" and match paragraphs (*A-F*) to the pictures (1-6).**



1. _____ 2. _____ 3. _____

4. _____

5. _____

6. _____

WHAT THREATENS OUR WORLD?

Today our planet is in a serious danger. The current state of environment has reached a crisis point. Air, water and soil pollution; global warming, ozone layer depletion, deforestation, nuclear and industrial waste, plants and animals extinction are among the most burning global issues.

(A) We are fast approaching a crisis where the world's demand for energy will outstrip the resources that are available to produce it. Moreover, the best scientific evidence suggests that burning fossil fuels is responsible for the global warming that we have witnessed over the past century. The problem is that apart from nuclear power, we still lack any truly viable ways of producing energy on a large scale that do not rely on burning oil, coal and gas. It is one of the biggest challenges of the 21st century: how can the world's ever-increasing demand for energy be met without causing further damage to the environment?

(B) It hardly ever occurs to us, but "water" also has its limits, especially drinking water. Since 1975 the demand for water has doubled worldwide. The lack of pure potable water is a fact for approximately 900 million people! Every day 20.000 up to 30.000 people die from lack of pure water, that's one every 8 seconds. Many of these are children. According to some statistics two people in three across the world will face water shortages by 2025. Many of these people will be forced from their homes to seek clean water supplies elsewhere.

(C) We can no longer ignore the evidence of environmental erosion: the destruction of tropical forests, home to over half of the planet's species; the shrinking of natural habitats due to demographic and urban growth; the slow death of coral reefs, nearly one-third of which have already disappeared or suffered serious damage; the sharp decline in the numbers of large wild mammals. Today, we know that nearly 16,000 known species are directly endangered. Our generation is probably the last with the power to stop this destruction before we reach a point of no return.

(D) We still, live, as all our ancestors have done, under the threat of disasters that could cause worldwide devastation: volcanic super eruptions, asteroid impacts and others. Consider the catastrophic tsunami in December 2006, which began 350 km off the north-western tip of Sumatra in Indonesia and spread quickly across the Indian Ocean killing some 300 000 people in Southeast Asia. In total, citizens from more than 30 countries were affected, with Sweden - a country far from the Indian Ocean - alone losing more than 550 lives.

(E) Cancer, according to recent reports, kills more people than do road accidents and air accidents put together. Cancer has become the most dreaded killer disease, striking more and more people.

Cancer is a double-edged sword. It strikes a patient physically and it causes tremendous mental trauma. It is very hard indeed to accept the fact that one has cancer. Then follow the long courses of treatment - chemotherapy, surgery and radiation. They say cancer is curable if detected early. Early detections do occur but these constitute a very low percentage of the total number of cancer cases detected.

(F) Scientists and researchers from various fields tell us that the effects of climate change could be far-reaching, and, in some cases, cause serious problems. For example, rising temperatures could increase pollution and reduce air quality in heavily populated urban areas, leading to an increase in respiratory and cardiovascular diseases. Moreover global warming will have economic implications. Among them are expensive clean-up operations from the possible increase in extreme weather such as more frequent and heavy rain falls in some regions, causing rivers to flood.

Coping with the world's most serious challenges will require a variety of solutions and contributions from researchers from a wide range of disciplines. Science – and physics in particular – can play a major role in solving the problems facing humanity.

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

Study help ***Reading for specific information***

Read the statements and underline the key words. Read the text to get the gist. Read again carefully. Look for synonyms/opposites or words/phrases with similar/different meanings to the key words in the statements.

a) The amount of the available fossil fuel resources doesn't meet the world's increasingly growing demand for energy. ( )
b) Except for nuclear power there is no other viable alternative to fossil fuels. ( )
c) Nowadays the humankind needs 20% more drinking water than it used to in the 1970s. ( )
d) In a few decades there will start a big migration of nations caused by people's search for clean water supplies. ( )
e) Forest destruction, overpopulation and urbanization lead to the decrease in the number of the planet's species. ( )
f) Unlike their ancestors people can now monitor natural disasters much better and as a result such catastrophes no longer bring worldwide devastation. ( )
g) Road and air accidents kill more people than cancer. ( )
h) Climate change, and global warming in particular, has undesirable consequences for the world economy and people's health. ( )

Focus on language

1. Study the words and word combinations in the box and classify them under the headings (1-2). Give their Russian equivalents.

Example:

1) ***Problems threatening humankind***: global warming
2) ***Disastrous consequences:*** increase in extreme weather

energy crisis	asteroid impact
damage to the environment	catastrophic tsunami
lack of pure water	expensive clean-up operations
increasing demand for energy	death of coral reefs
water shortages	cancer
environmental erosion	mental trauma
destruction of tropical forests	rising temperatures
shrinking of natural habitats	increase in diseases
decline in the number of species	heavy rain falls
climate change	pollution
worldwide devastation	reduced air quality
volcanic eruption	endangered species
economic implications	flood

2. Complete the table. Turn the words given in the table into *verbs, nouns* and *adjectives*. Use a dictionary if necessary.

VERB	NOUN	ADJECTIVE
	damage	
challenge		
	increase	
	reliance	
destroy		
	erosion	
		developing/developed
		urban
contribute		
pollute		
decline		
	threat	
endanger		
	devastation	
		(in)curable
reduce		
	contamination	
		(non)renewable

Add new vocabulary to your vocabulary notebook. ✍

3. Fill in the gaps with the right form of the words in capitals.

Study help ***Word formation***

Read the sentence to get an idea what it is about. For each gap decide what part of speech the missing word is e.g. noun, verb, adverb, participle, etc. You may need to write the word in the plural or with a negative meaning. Think of prefixes and suffixes. Fill in the gap(s). Check the spelling. Read the completed sentence to check if it makes sense.

a)	The difficulty of putting our ideas into practice …….. us to find a new method.	CHALLENGING
b)	We are worried by the …….. amount of carbon dioxide in the atmosphere.	INCREASE
c)	These days, a lot of …….. animals are being killed by hunters and poachers.	DANGER
d)	The existence of nuclear weapons poses a serious …….. to the future of the world.	THREATEN
e)	More money should be given to do medical research into …….. diseases, such as Alzheimer's.	CURE
f)	Many rivers and lakes have been badly …….. by industrial waste.	CONTAMINATION
g)	The …….. number of whales in the oceans is one of the major concerns for marine biologists.	DECLINE
h)	When fuels like oil and gas are being burned they release ……., which trap heat in the earth's atmosphere.	POLLUTE
i)	It is very expensive to restore historical structures and buildings …….. by acid rain.	DAMAGE
j)	The …….. of the protective ozone layer has caused many more cases of skin cancer.	REDUCE
k)	Fossil fuels pollute environment and are not ……, so once we have burned them all up, there will be no more.	RENEW

Discuss

- Which of the threats described in the text "What threatens our world?" are true for your country?
- Are there any solutions to these problems? What are they?
- Which fields of science could help to solve some of the global issues? In which way?

LISTENING

1. Listen to an interview with Professor Steve Cowley from the Culham Fusion science centre in Oxfordshire talking about cleaner nuclear energy production. As you listen complete the tasks (1-6).

1) Match the words with their definitions.

1. fusion **2. fission**

a. splitting very big atoms, nuclei of atoms
b. joining very small atoms together to make bigger nuclei

2) Why is it not easy to get two small atoms really close to each other so that they stick together?

3) What two types of forces are there inside the nucleus? How do they act?

4) What are the names of the two kinds of hydrogen in the picture?

5) What two things are needed to make fusion happen in a laboratory experiment?

6) Why is fusion viewed as a clean source of energy?

2. Fill in the gaps in this interview extract with the words from the box. Listen again and check.

splitting	iron	stick	short	nuts and bolts
powers	nuclei	stable	grab	long	gain
joining	hydrogen	same	repulsion	medium-sized

Chris - Welcome to the Naked Scientists. How does fusion differ from fission, the thing that **1)** _____ the nuclear power stations we have here in Britain?

Steve - Behind all these ways of making energy is the fact that the most **2)** _____ nucleus of an atom happens to be **3)** _____, right in the middle of the periodic table. It's a **4)** _____ nucleus. Any way you can go towards it you can **5)** _____ energy. Fission is **6)** _____ very big atoms, nuclei of atoms to go towards iron. Fusion is **7)** _____ very small ones together to make bigger **8)** _____ to go towards iron.
It turns out that the easiest reactions to do with fusion are to join **9)** _____ together to make helium.

Chris - Let's look at the **10)** _____ of the fusion process then.

Study help **Gap-filling**

Read the text through to get an idea of what it is about. Read again and focus carefully on the words before and after each gap. Choose the word that fits best. Read through the completed text again to check that it makes sense.

Steve - The problem with fusion is that in order to get them to **11)** _____ together you have to get them really close. There's a force in the nucleus which is called the strong force. It only acts over a very **12)** _____ distance. There's another force which is the electric force which acts over a **13)** _____ distance. When you've got two nuclei far apart they repel each other because they're the **14)** _____ charge. Two nuclei are both positive charges. They repel. When you get them really close together they **15)** _____ each other and stick. To get them that close you have to get over that **16)** _____ all the way.

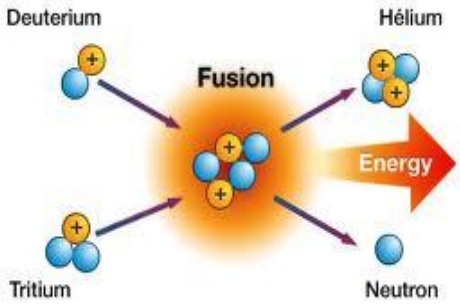
READING

1. **Work in pairs. Discuss the question.**

✓ Can physics help solve any of the global problems of humankind? Which problems and in which way?

2. **Read the extracts (*A*-*G*) to learn more about the potential of physics for solving global problems. Compare the information in the extracts with your answers to the question in Task 1.**

A) Physics will play a critical role in 'sustainable development'. Taking clean water as an example, membranes that are made from carbon nanotubes can be used to block the passage of bacteria, viruses, heavy metals and other pollutants. They can therefore be used as effective filters for purifying water. Several laboratory experiments have demonstrated that carbon-nanotube filters can remove viruses 25 nm in size from water, as well as larger pathogens such as *E. coli* and *Staphilococcus aureus* bacteria. Carbon nanotubes can also withstand a relatively high temperature, which means the filter could be unclogged periodically by heating it; conventional polymer-based water filters, in contrast, are destroyed if heated.



B) There is a need for research into new reactor designs and alternatives to the conventional nuclear-fuel cycle. In the longer term, fission could be replaced by fusion power. Fusion power is believed to have significant safety advantages over current power stations based on nuclear fission. In a fusion reactor there is no possibility of runaway heat build-up or large-scale release of radioactivity, little or no atmospheric pollution, the power source comprises light elements in small quantities, the waste products are short-lived in terms of radioactivity. A commercial fusion reactor is unlikely to become a reality until about 2050, however.

C) Particle physicists spend most of their time exploring the fundamental properties of matter, often with accelerators that cost hundreds of millions of pounds. However, some are also engaged in a more down-to-earth activity – developing new technology for medical applications. Technologies originally developed for experiments in particle physics are being used to diagnose and treat cancer. The devices are designed to ensure that a patient undergoing intensity modulated radiotherapy (IMRT) receives precisely the right dose of radiation. IMRT involves dividing the cross-sectional area of an X-ray beam into segments of different intensities. This allows clinicians to vary the radiation dose across a tumour, and more precisely match the shape of that turmour. It also means they can reduce the impact of radiotherapy on healthy tissue.

D) Meeting the world's energy demands in an environmentally acceptable way will require the development of new sources of renewable energy. There is, however, one very big problem: renewable energy is currently much more expensive than other sources of power.
Reducing the cost of renewable energy is a challenge for researchers from a wide range of disciplines, including mechanical and electrical engineering, materials science, physics, chemistry and, occasionally, biology. Physicists have a much greater involvement in areas where more fundamental research is required. Chief among these areas is photovoltaics. Photovoltaic cells are semiconductor devices that convert sunlight directly into electricity.

E) More research is needed on thermovoltaic cells, which are sensitive to infrared (heat) radiation, rather than visible light, and have potential to handle far greater power densities than standard cells. Thermovoltaics can convert solar energy and also capture waste heat from existing industrial and electricity-generating processes. Heat in a solar thermal system is guided by five basic principles: heat gain; heat transfer; heat storage; heat transport; and heat insulation.

F) Many renewable sources, however, can only generate electricity at certain times, such as when it is windy or sunny; so much of the energy produced will need to be stored. At present, physics-based companies are carrying out considerable research and development in energy-storage technologies, such as utility batteries, fuel cells, flywheels, superconducting magnets, compressed-air storage, pumped hydropower and super capacitors.

G) Technology developed by particle physicists has already led to a number of breakthroughs in medical imaging, including positron emission tomography (PET), magnetic resonance imaging (MRI), computed X-ray tomography (CT) and molecular imaging.
The various existing imaging technologies differ in five main aspects: (1) spatial resolution; (2) depth penetration; (3) energy expended for image generation; (4) availability of injectable/biocompatible molecular probes; and (5) the respective detection threshold of probes for a given technology. In addition, linear accelerators are used to provide energetic photons for radiotherapy.

3. Choose the best answer (*a, b* or *c*) to complete the sentences (1-6).

1) Carbon nanotubes...
   a) can kill bacteria and viruses in drinking water.
   b) get destroyed under high temperature.
   c) can improve the efficiency and durability of water purifying filters.

2) Fusion power …
   a) is being used on most nuclear power plants nowadays.
   b) has essential security advantages over currently used technology.
   c) will replace fission power in the near future.

3) Nuclear power…
   a) might become mainstream in a few decades because fission would be replaced by fusion power.
   b) produces radioactive waste that cannot be utilized.
   c) could never become a good solution to energy crisis.

4) Medical technologies based on developments in particle physics…
   a) require huge financial investments.
   b) allow doctors to effectively control the radiation dose for oncological patients and get detailed imaging of some organs.
   c) focus on diagnostics rather than treatment.

5) The main problem with renewable energy is that…
   a) it cannot be stored.
   b) now it is less cost efficient than fossil fuels.
   c) it requires the development of energy storage technologies.

6) Photovoltaic and thermovoltaic cells …
   a) are similar.
   b) are absolutely different.
   c) are both used for generating electricity from solar energy.

Focus on language

1. Read the sentences and translate them into Russian. Pay special attention to the words in bold.

- *Photovoltaic cells are semiconductor devices **that** convert sunlight directly into electricity.*
- *The catastrophic tsunami in December 2006, **which** began 350 km off the north-western tip of Sumatra in Indonesia, spread quickly across the Indian Ocean and killed some 300 000 people in Southeast Asia.*
- *Physicists have a much greater involvement in areas **where** more fundamental research is required.*
- *Carbon nanotubes can also withstand a relatively high temperature, **which** means the filter could be unclogged periodically by heating it.*

2. Study the rules in the box and apply them to analyze the sentences in Task 1. Use these rules to make up sentences in Task 3.

Relative clauses with *which, that, who, whose , where, when* and *why*

Relative clauses begin with a relative pronoun or a relative adverb.

We use:

- **Who(m)/that** to refer to people.

  *The man **who/that** is talking to a student is our new physics teacher.*

- **Which/that** to refer to things.

  *The proposed research will concentrate on developing a robot **which/that** is able to gather readings in three dimensions.*

- **Whose** with people, animals and objects to show possession.

  *A good lab assistant is the one **whose** equipment works well.*
  *That's the device **whose** parts were destroyed by fire.*

- **When/that** to refer to a time.

  *That was the year **(when/that)** Albert Einstein formulated his famous relativity theory.*

- **Where** to refer to a place.

  *The Cavendish laboratory **where** Pyotr Kapitsa worked with Ernest Rutherford belonged to the university of Cambridge.*

- **Why** to give a reason.

  *The reason (**why**) the experiment failed is still unclear.*

- If relative clauses give essential information they do not have commas.

  *With fusion we aim to produce a power **that** has no long-lived radioactive waste.*

- If relative clauses give extra information that can be left out, they have a comma before the clause and a comma or a full stop after it.

  *My junior brother wants to study in Boston university, **where** I did my postgraduate course.*

- **Who, which** and **that** are not omitted when they are the subject of the relative clause.

  *The man **who/that** is talking to a student is our new physics teacher.*

- **Who, which** and **that** can be omitted when they are the object of the relative clause.

  *The book (**that/which**) he is reading now is about great space explorers.*

- **Which** can be used in a relative clause to refer to the whole sentence.

  *Acid rain makes soil highly acidic, **which** leads to the drying and death of forests.*

- **What** is used in relative clauses to mean ***the thing that.***

  ***What** the lecturer said about the consequences of acid rain was shocking.*

- **Whom, which** and **whose** can be used in expressions of quantity with **of** (some of, many of, half of, etc)

  *She got a lot of job offers, **most of which** were from IT companies.*

3. Join the sentences using *who, that, which, whose, when* or *where.*

Example:

She suggested an idea. It was interesting.

*The idea (**which/that**) she suggested was interesting.*

a) Isaac Newton was an English physicist, mathematician, astronomer and philosopher. He formulated the Law of Universal Gravitation.
b) Vehicle exhausts contain nitrogen oxides, hydrocarbons and other chemicals. They are hazardous to health and the environment.
c) The idea of nanotechnology was born in 1959. In that year Richard Feynman gave a lecture exploring the idea of building things at the atomic and molecular scale.
d) Acid rain assaults buildings and water pipes with corrosion. It costs millions of dollars every year.
e) The ancient Romans built their famous aqueducts to take the waste out of the city. They understood the connection between sewage and disease.
f) The atmosphere is the layer of gas. It surrounds the earth.
g) The evidence of environmental erosion is the slow death of coral reefs. One-third of coral reefs have already disappeared or suffered serious damage.
h) Nuclear power stations are not carbon free. At these stations fossil fuels are needed to run the nuclear cycle.
i) Nuclear power is a mature technology. Its reliability has been proven over years.
j) Over the past century we have witnessed global warming. Global warming is caused by burning fossil fuels.
k) Intensity modulated radiotherapy (IMRT) allows clinicians to vary the radiation dose across a tumour. It means that doctors can reduce the impact of radiotherapy on healthy tissue.
l) These technologies are now being used to diagnose and treat cancer. They were originally developed for experiments in particle physics.
m) The nucleus has a force called the strong force. It only acts over a very short distance.
n) Experimental nanotechnology appeared only in 1981. In that year IBM scientists in Zurich, Switzerland, built the first scanning tunneling microscope.

Get real

Search the Internet and/or popular science magazines to find out more about the global problems threatening humankind. Choose the one you find most disastrous and prepare a PowerPoint presentation about it. Make use of these questions:

- ✓ **What causes this problem?**
- ✓ **What are the disastrous consequences?**
- ✓ **What are the possible solutions?**
- ✓ **How can physics contribute to the solution of the problem?**

SPEAKING

Make your presentation in class. Make sure you structure your talk properly and use signpost words to help the audience follow your ideas.

Study help ***Signposting in speaking***

Speakers make use of special words to help introduce ideas and to provide a framework for what they are saying, especially in formal speech, such as a lecture or a talk. We can think of these words as 'signpost words' because they direct our listening: in other words, they warn us that more information is coming and suggest what kind of information this may be: e.g. additional, positive, negative, similar, different. They may also introduce examples of a main point made earlier.

Some signpost words:

- Leading towards a comparison — ***It's like ... It's as if...***
- Leading towards a contrast or opposite — ***Despite, In spite of, On the one hand, On the other hand, However, Although, Though…***
- Introducing an example of what was said earlier — ***For instance, For example, Let me give you an example, such as ...***
- Suggesting cause and effect or result — ***In consequence, Consequently, It leads to/results in…, As a result ….***
- Providing additional information — ***Besides, Also, Moreover, In addition …***
- Setting out the stages of a talk — ***Firstly…, Secondly… and thirdly; First…, Then…, Next…, Finally…***

Summarizing

1. **Read the text "Энергия XXI века?" and highlight the Russian equivalents to the English word combinations (1-15).**

1) search for alternative sources of energy/alternative energy sources
2) a more environmentally friendly and more cost-effective energy source
3) to meet the demands of humankind for energy
4) to be a viable alternative to oil, gas and coal
5) solar power, hydrogen fuel cells, biofuel
6) the most promising energy sources of the 21st century
7) the main disadvantage/shortcoming of something
8) the high cost of the equipment
9) to harvest energy

10) to depend on weather and atmospheric conditions
11) to develop the concept of wind power stations
12) to transfer power to the earth via the cable
13) something like a 'kite' with a turbine
14) nuclear power/fission/fusion
15) to develop thermonuclear reactors

Add new vocabulary to your vocabulary notebook. ✍

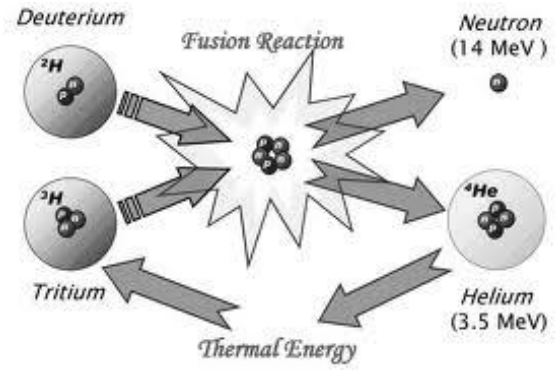
Энергия XXI века?

Все мы слышали о поисках «альтернативных источников энергии», но в реальной жизни пока не видно особых изменений. Ученые пытаются найти более чистый с экологической точки зрения, и более эффективный с экономической источник энергии, дабы сохранить нашу планету и, в то же время, удовлетворить потребности человечества. Удастся ли им это? Есть ли реальная альтернатива нефти, газу и углю?

Уже сейчас можно услышать о применении солнечной энергии, водородных топливных элементов, биотоплива и многого другого. Каковы же наиболее перспективные виды энергии XXI века?

Доступная энергия, не загрязняющая окружающую среду, буквально падает на нас с неба. Солнечные лучи несут довольно много энергии, но основными недостатками солнечной энергии являются высокая стоимость оборудования и необходимость больших пространств для сбора значительного количества энергии. К тому же получение такой энергии сильно зависит от погоды и атмосферных условий.

На сегодняшний день энергия ветра удовлетворяет лишь 0,1% потребностей человечества в электричестве. Но в будущем прогнозируется рост ее доли. Развивая концепцию ветряных электростанций, ученые предложили добывать энергию ветра на высоте 4,6 километра. Некие устройства с пропеллерами (которые также могут работать в качестве турбин) будут висеть в воздухе и передавать энергию на землю по кабелю, что-то вроде «воздушного змея» с турбиной.



Атомная энергия, несмотря на все её опасности, является важным источником энергии. Сейчас для получения энергии используется ядерный распад, но ученые работают над созданием генераторов, работающих на принципах ядерного синтеза. Также не стоят на месте и разработки термоядерных реакторов.

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

WRITING

Read the quotations (1-4). Choose the one you like best and write an essay to express your opinion.

1) **"It would indeed be a tragedy if the history of the human race proved to be nothing more than the story of an ape playing with a box of matches on a petrol dump."** David Ormsby Gore

2) **"The more humanity advances, the more it is degraded."** Gustave Flaubert

3) **"Human beings invent just as many ways to sabotage their lives as to improve them."** Mark Goulston

4) **"Evolution is individual - devolution is collective."** Martin H. Fischer

Study help ***Opinion essays***

Opinion essays require your clear opinion on a topic, supported by reasons and examples. They should contain: an **introduction** (stating the topic & your opinion), a **main body** (several paragraphs each with a topic sentence presenting a separate viewpoint supported by reasons/examples, and a paragraph presenting the opposing viewpoint) & a **conclusion** (relating your opinion in other words).

Points to consider:

- Decide on your opinion before you start writing i.e. whether you agree/disagree and how strongly, as this will affect the structure of your essay.
- Use present tenses and formal style, avoiding colloquial expressions, short forms and personal examples.
- Include phrases to express your opinion, a variety of appropriate linking words and interesting techniques to begin/end your essay, e.g. a quotation, a rhetorical question, etc.

Functional Language

To express opinion	In my opinion/view, It seems to me that… To my mind, I (strongly/completely) agree/disagree/believe that… I am totally against…
To list points	First of all, In the first place, Firstly/Secondly, To start with, To begin with
To add more points	Also, Moreover, Furthermore, In addition, Besides, Apart from this, Another major reason
To introduce contrasting viewpoints	On the other hand, However, It is argued that… Opponents of this view say
To introduce examples	For example/instance, such as, in particular, especially…
To conclude	To sum up, In conclusion, All in all, All things considered, Taking everything into account…

Here are some words and phrases that can be useful when you speak about global problems of humankind and their possible solutions. Read the definitions and think of the proper equivalents in Russian.

fossil fuel	Any hydrocarbon deposit that can be burned for heat or power, such as petroleum, coal, and natural gas.
greenhouse gases(GHG)	Gases present in small quantities in the atmosphere which absorb a part of the energy reemitted by the Earth and enable it to maintain an average temperature which can support life: water vapour (H2O), carbon dioxide or carbonic gas (CO2) and methane (CH4). Their sharp increase due to human activities is the main cause of climate change.
greenhouse effect	The rise in temperature that the Earth experiences because certain gases in the atmosphere trap energy from the sun. Because of their warming effect, these gases are referred to as greenhouse gases. Without them, more heat would escape back into space and the Earth's average temperature would be about 33ºC colder. Similarly, their rapid accumulation in the atmosphere can lead to rising temperatures.
non-renewable resource	A resource that is not replaced or only replaced very slowly by natural processes.
renewable energy	Natural and inexhaustible energy sources. The first of these is the sun's rays and the others follow more or less directly (wind, water cycle, tides, manufacture of biomass, etc.).
chlorofluorocarbons (CFCs)	A family of inert nontoxic and easily liquified chemicals used in refrigeration, air conditioning, packaging, and insulation or as solvents or aerosol propellants. Because they are not destroyed in the lower atmosphere, they drift into the upper atmosphere where their chlorine components destroy ozone.
heavy metal	A high-atomic-weight metal such as arsenic, cadmium, chromium, cobalt, lead, mercury, uranium or zinc. Heavy metals can be toxic to plants or animals in relatively low concentrations and tend to accumulate in living tissue.
deforestation	The removal of forests by cutting and burning to provide land for agricultural purposes, residential or industrial building sites, roads, etc. or by harvesting the trees for building materials or fuel.
habitat	The natural home of a plant or animal.
environmental impact	Anything which causes the deterioration of our environment, either by using non-renewable resources (oil, coal, plastics, etc.) or by producing harmful products (waste, air, water and soil pollution).
sustainable development	Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
green technology	The adoption of environmentally friendly tools and methods for energy production, industry, and agriculture.

Progress Monitoring

In this unit you have worked on the vocabulary on the topic: "Physics for Solving Global Issues".

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

1. scientific evidence
2. fossil fuels/renewable energy
3. to cause serious problems/damage to sth
4. to face water shortages/lack of pure water
5. destruction of forests/deforestation
6. shrinking of natural habitats
7. to reach a crisis point/a point of no return
8. a threat of disasters
9. a double-edged sword
10. far-reaching effects of sth
11. to have economic implications
12. global/environmental issues
13. to cope with challenges
14. fission/fusion nuclear power
15. sustainable development
16. to have significant advantages over sth
17. environmentally acceptable way
18. to require fundamental research
19. to develop technologies for medical applications
20. to reduce the impact of sth on sth

Progress Test

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

a) damage, danger, destruction, devastation
b) shrinking, reduction, challenge, decline
c) demand, growth, rise, increase
d) to endanger, to affect, to strike, to detect
e) pollutants, bacteria, viruses, pathogens
f) accelerators, flywheels, capacitors, applications

2. Give English equivalents to these Russian word combinations.

a) устойчивое развитие
b) ископаемое топливо
c) возобновляемая энергия
d) топливный элемент
e) энергия ядерного синтеза
f) текущее состояние окружающей среды
g) момент, с которого возвращение назад невозможно/точка невозврата
h) далеко идущие последствия

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

e.g. ['baɪəukəm'pætəbl] – biocompatible – биосовместимый

a) ['hæbɪtæt]
b) [ˌɪnsjə'leɪʃ(ə)n]
c) ['spiːʃiːz]
d) ['vaɪərəs]
e) [ˌθɜːmə'njuːklɪə]
f) ['tjuːmə]
g) ['haɪdrədʒən]

4. Put in *which, who* or *that.*

a) The skill and inventive genius of physicists and engineers have led to the development of many of the instruments and techniques …… form a vital part of modern medicine.
b) Alexander Bell was the man …… invented the telephone.
c) The world's population is growing very fast …… makes the world critically short for food and water.
d) The physical scientists …… work in medical physics and engineering may be physicists, engineers, applied mathematicians or computer scientists.
e) The medical physicist is called upon to contribute clinical and scientific advice and resources to solve the numerous and diverse physical problems …… arise continually in many specialized medical areas.
f) Our modern lifestyle is destroying the fragile environment …… leads to the environmental catastrophe.

UNIT 10

A JOB FOR A PHYSICIST

The answer most appropriate for the question:
"What Does a Physics Major Do?" is: anything they want to do.
WorldWideLearn.com

Learning Objectives

In this unit you will:

- ✓ revisit vocabulary for describing skills and personal qualities
- ✓ revisit patterns with the Infinitive and Gerund
- ✓ practice word building
- ✓ talk about possible career paths for physics graduates
- ✓ write a CV and Cover letter
- ✓ build and comment on a diagram of career choices
- ✓ practise summarizing skills

LEAD IN

1. **An American teenager in his blog comes up with the following questions:**

It's about the end of the high school year. I'm going to college. Let's see... What major should I choose? I'm keen on physics but I just can't make up my mind! Any recommendations? OK! Please give your own opinions and answers to some questions below and share your experience in choosing "what to learn" at college. Thank you.

1) What jobs for physicists do you think are the hottest nowadays?

2) Do you think with a BSc in physics, I can easily get a job with high (or at least, acceptable) salary which can provide me enough money to continue my study? I want to get an MSc and then possibly, a PhD.

3) Is it actually easy to get a job with major in nuclear engineering? (I'm really interested in nuclear physics).

How would ***you*** answer these questions? What would you recommend this high school leaver?

Work in groups. The chart below will help you to brainstorm ideas.

Job	Possible place of work	Advantages
1. nuclear engineer	nuclear power plants, military industry, medicine, etc.	in great demand, well-paid, possibilities of overseas employment
2.		
3.		

2. **Sum up your ideas and share them with the rest of the class.**

READING

1. Give the Russian equivalents to the phrases on the list. Compare your list with a partner's. Use a dictionary if necessary.

- daunting prospect
- to be passionate about sth
- a topic of current interest
- to opt to do a Master's (degree)
- to require a Master's-level qualification
- to pursue a career
- to provide an opportunity
- to broaden one's knowledge
- academic or research career
- work environment
- shortage of skills
- creative profession
- to remain in touch with the scientific community
- taught/research-based degree
- educational techniques
- rewarding feeling

2. Read the text on *page 138* to find out more about possible career paths for physics graduates. Make notes under these headings.

- **Areas of employment**
- **Skills required**
- **Degrees/qualifications required**

Where next?

3. Answer the questions.

a) What are the two types of a Master's degree in the UK? What does each type involve?
b) What are the benefits of taking a PhD course?
c) Can one with the Bachelor's degree find an interesting and well-paid job?
d) What options are available for those who are not very keen on research but want to remain in touch with the scientific community?
e) What businesses are open for physics graduates?

4. Match the expressions in column *A* with their meanings in column *B*.

A	B
1) to stand sb in good stead	a) to be much better or more important than sb/sth
2) to remain in touch with sth	b) stay informed about sth
3) to stand out	c) be advantageous or useful to someone in the future
4) in the main	d) there is no limit to the opportunities open to you
5) keep up to date with sth	e) used to say that a statement is true in most cases
6) the world is your oyster	f) to know what is happening in a particular subject or area

NEXT STEP FOR PHYSICS GRADUATES

Leaving university is an exciting but daunting prospect for most students. Everyone knows that with a physics degree on your CV the world is your oyster, but this does not mean that deciding what to do next is easy. There are, quite simply, so many options available. One of the first decisions you need to make is whether to continue studying.

Where next?

In the UK, a Master's degree can be either taught or research-based. Taught Master's involves attending various classes, producing course work, taking exams and writing a dissertation of 10,000–20,000 words on a topic of current interest in your chosen research field. It lasts one year and Master of Arts (MA) or Master of Science are the standard degrees awarded at the end of the course. In contrast, research-based Master's focuses more on independent and individual rather than classroom work. It includes both research methods training in the relevant discipline and a substantial research project which is essentially a miniature PhD. Research-based degree lasts two years and leads to the qualification of MPhil (Master of Philosophy).

Graduates usually opt to do a Master's because they want to broaden their knowledge by studying a new subject area or because they want to pursue a career, for example in medical physics that requires a Master's-level qualification.

PhDs are in the main undertaken by those thinking of pursuing an academic or research career. When you come to apply for jobs, having a PhD will help you stand out in many commercial sectors because it shows you can work independently and can master a topic to a very deep level of understanding. In finance, for example, physicists are often employed as "quants" — specialists in quantitative finance who deal with risk management and financial products such as derivatives and options. Becoming a quant is almost impossible without the mathematical and problem-solving skills that you learn during a PhD.

Getting out of the classroom

If you decide to join the world of work straight after your first degree, however, you will find yourself in a strong position. As a physics graduate you should have no shortage of skills. As well as being highly numerate, analytical and logical, the chances are that you are also a creative thinker, excellent at problem solving and meticulous — skills that are relevant in any work environment.

Where do physics graduates go?

If you enjoy research but want to leave academia behind, then a large company such as Philips, QinetiQ, Rolls-Royce or Siemens could be a good option. Not only do these firms spend a lot of money on research and development, they also employ large numbers of graduates.

There are also many job opportunities for physicists in the renewable-energy sector, for example with energy companies such as E-ON, and Npower. Big oil companies like BP, Shell and Schlumberger also have major research and development projects into technologies such as solar cells where physicists have a role to play.

There are also opportunities for physicists in nuclear power, which seems to be undergoing something of a renaissance at the moment.

Beyond the lab

If research is not for you but you still want to remain in touch with the scientific community, then you might want to consider science communication. This is an umbrella term for roles — usually in public relations or journalism — that involve presenting scientific information to a more general audience, be it fellow scientists or the general public. These jobs often require a Master's in science communication, although practical skills gained on university newspapers and magazines are also highly regarded. There are also opportunities in publishing for physicists who want to work as publishers or production editors of scientific journals.

Beyond science, physics graduates tend to work in business services (law, accountancy, management consultancy, patent work and so on) as well as financial services, education and manufacturing. Teaching also provides an opportunity for those with good communication skills to make a real impact.

Getting a complex scientific point across to a group of students can be an incredibly rewarding feeling. Indeed, teaching can be a very creative profession, in which you can continuously improve your lessons with new material and keep up to date with the latest educational techniques.

A helping hand

These are just a few of the careers available to physics graduates. With the right training you could become anything from an aeronautical engineer to a meteorologist. The hardest thing is deciding what you want to do.

A physics degree stands you in good stead, so make sure that you sell it for what it is actually worth. But whatever you decide to do — make your millions, ensure the planet is safer place or to just take a year out — the most important thing is to make sure you enjoy it.

Focus on language

1. Complete the chart. Use a dictionary if necessary.

NOUN	VERB	ADJECTIVE
		creative
	decide	
	opt	
		relevant
management		
		industrial
specialist		
	solve	
communication		
	employ	
editor		
		various
	consider	
qualification		

Add new vocabulary to your vocabulary notebook. ✍

Verb patterns with the Infinitive

There are two typical verb patterns with the infinitive:

Verb + Infinitive

*They **decided to pursue** a career in science.*

agree	arrange
ask*	decide
expect	fail
attempt	hope
learn*	threaten
manage	offer
promise	refuse
remember*	seem
tend	try
use	want

when they are followed by question words (who, what, where, how, etc.)

Verb + Object + Infinitive

*PhD **helped** me **to stand** out in the company.*

advise*	allow*
ask	enable
expect	encourage*
want	warn
force	remind
help	teach
tell	motivate
order	persuade
invite	recommend*
forbid	instruct

***** *if followed by an object or in a passive form*

2. **Complete the sentences with the most suitable verb from the table on page 139. Think of the appropriate tense form of the verb. Sometimes more than one verb is possible.**

a) I strongly _____ you to attend Professor Gordon's lectures on quantum mechanics.

b) I'm glad you _____ to submit your lab report before the deadline.

c) He _____ to double check the results of the experiment.

d) We hope the accelerators _____ us to explain the structure and origin of all matter.

e) My parents always _____ me to be creative and independent.

f) The new equipment installed in our lab _____ students to perform their laboratory work with better results.

g) Nowadays more and more school leavers _____ to choose physics as their speciality.

h) Jill _____ to take a Master's degree course.

i) This dispute _____ to split the team into two opposing camps unable to collaborate!

j) I can't believe so many students _____ to join the university's Digital-Gaming Society!

3. **Which verbs in the table haven't been used? Make use of them in the sentences of your own.**

Verb patterns with the Infinitive and Gerund

Some verbs change their meaning followed by the Infinitive or Gerund.

try	be sorry	be afraid	stop	like
mean	remember	forget	regret	go on

Verb + Infinitive	**Verb + Gerund**
*I'**m sorry to interrupt**, but can I ask you a question*? (to apologise for a present action)	*I'**m sorry for making** a mistake like that!* (apologise for an earlier action)

4. **Study the pairs of sentences and explain the difference in meaning. Use a dictionary if necessary. Translate the sentences into Russian.**

1. a) I ***tried to solve*** the problem suggested by my supervisor but I couldn't.

   (I made an attempt/effort to do it but I was unsuccessful)

   b) Why don't you ***try getting*** some more information about this phenomenon?

   (You should do it as an experiment or test)

2. a) You've improved a lot, but you still ***need to work*** harder.

   b) I'm afraid my computer ***needs upgrading***.

3. a) I ***stopped to buy*** a new issue of the 'New Scientist' magazine.

   b) They ***stopped talking*** and concentrated on the experiment.

4. a) I ***like doing*** experiments, it's so exciting!

   b) I ***like to do*** experiments under the supervision of our lab instructor.

5. a) I will never ***forget taking part*** in the international conference on biophysics in Spain.
   b) Don't ***forget to check*** the voltage before you start the experiment.
6. a) Don't ***be afraid to participate*** in the discussion ***and say*** what you think.
   b) While experimenting I ***was afraid*** **of doing** something wrong.
7. a) I ***remember reading*** a lot of sci-fi books about space travel.
   b) Please ***remember to follow*** safety instructions while working in the lab.
8. a) I didn't ***mean to interrupt*** you, but how do you explain this formula?
   b) Being a researcher often ***means working*** overtime.
9. a) Although nobody believed it could be possible, he ***went on experimenting*** and made a great discovery.
   b) The lecturer stopped talking about the black holes and ***went on to talk*** about the recent findings on galaxy formation.

Verbs patterns with Gerund

Verb + Gerund

keep (on)	deny	admit	avoid
spend (time)	involve	suggest	continue
look forward to	can't help	risk	consider
mind	prefer/enjoy/hate	have difficulty (in)	imagine

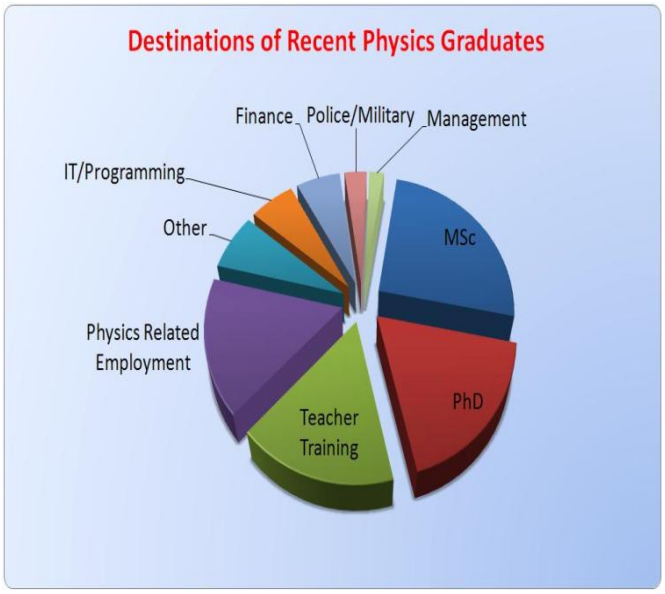
*e.g. We **enjoyed making** observation of the Moon eclipse.*
*Scientists **are looking forward to seeing** an impressive explosion of supernova.*

5. Choose the correct form of the verb.

a) The teacher decided *(accepting/to accept)* the paper.
b) Can you imagine *(living/to live)* without cell phones and computers?
c) We arranged *(meeting/to meet)* after the lecture.
d) Despite his first failure he kept on *(fixing/to fix)* the equipment necessary for the experiment.
e) I simply can't help *(missing/to miss)* some lectures at the university, they are dead-boring.
f) Would you mind *(testing/to test)* the equipment before using it?
g) Good communication skills help scientists and researchers *(getting/to get)* their message across.
h) You don't seem *(knowing/to know)* the solution to the problem.
i) They knew they risked *(not to be/being)* acknowledged by scientific community.
j) The data recently obtained from the Hubble telescope allows us *(knowing/to know)* more about the early universe.

SPEAKING

1. **The diagram (pie-chart) illustrates the typical career choices made by Physics graduates from Lancaster University. Comment on the diagram. Make use of the *Functional language* box and the models (1-5).**



Functional language ***Making comparisons***

… seems to be/is definitely

more/less	interesting	than…
	popular	
	stimulating	
the most/least	prestigious	
	challenging	
	secure	
	rewarding	
	attractive	
	exciting	
the highest/best-	paying/paid	

1) This diagram shows that/how many … and compares …

2) The diagram has nine segments: …, …, … and …

3) It can be seen that…
This suggests that…
It is interesting to see that…

4) As can be seen in the diagram/segment…
It is clear from the size of the segment that…

5) The greatest number (percentage) of graduates…
As many as/Far more…
The majority/Fewer/Far fewer…

2. **What would the pie-chart for career choices made by your faculty graduates look like? Work in small groups. Brainstorm the ideas and build a similar pie-chart. Present it to the class.**

READING

1. Read the advertisement for the job of Image Scientist. Answer the questions.

a) Is the job suitable for undergraduate students?
b) What duties and responsibilities does the job involve?
c) What knowledge and skills are required?
d) What personal qualities does the employer look for?
e) Which areas does the ITT Space Systems Company work in?
f) Where is the company located?
g) How could you apply if you got interested in the job?

Image Scientist

ITT Space Systems Division is seeking Imaging Scientists for locations in Rochester, NY and Vienna.

Location: ITT Space Systems Division ROCHESTER, New York, the USA

Interest Area(s): Aerospace, Remote Sensing & Astronomy, Optical Science & Engineering, Signal & Image Processing, Defense & Security

Education Level: Bachelor's Degree
Employment Type: Full Time/Part time
Position Type: Entry Level
Travel Required: Up to 25% Travel Required

Job Description:
ITT Space Systems Division is seeking Imaging Scientists for locations in Rochester, NY and Vienna. Positions entail working with image processing and dissemination systems. These positions are analytical in nature and include working in the areas of image chain analysis, image system modeling and simulation, image system optimization and calibration, image enhancement and fusion and algorithm development. You will work on state-of-the-art, team oriented projects, with opportunity for regular customer interaction.

Requirements include:

- Bachelor's degree in technical discipline with emphasis in physics, mathematics, engineering, image science or equivalent.
- Ability to develop and utilize analytical tools to predict imaging performance metrics
- Ability to develop and utilize image processing algorithms
- Fundamental understanding of image processing and remote sensing
- Excellent mathematical skills and a technical understanding of imaging systems and related tools, MS Office (Word, Excel and Power Point).
- Strong interpersonal and customer interaction skills.

Contact David Appleby
Company Name: ITT Space Systems Division
Address: Rochester New York United States
Phone: 0(950) 344 675 231
Apply at: http://www.ssd.itt.com

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

a) look for, hunt for, search for
b) picture, illustration, representation
c) logical, systematic, methodical
d) model, mock-up, imitation
e) improvement, development, enrichment
f) high-tech, up-to-date, modern
g) superb, first-rate, exceptional
h) stress, importance, prominence
i) exploit, use, employ
j) connected, linked, associated

Get real

Search the Internet to find some tips and/or 'rules' for writing a CV. Discuss them as a class and create a Writing a CV Factsheet. Make use of these guidelines:

- ✓ sequence
- ✓ length
- ✓ writing style
- ✓ format
- ✓ organization

Study Help

A Curriculum Vitae, commonly referred to as **CV** [kə'rɪkjələm] ['viːtaɪ]/['vaɪtiː] or (AmE **resume** ['rezjuːmeɪ]) is a written record of your education and the jobs you have done, that you send when you are applying for a job. It is a detailed summary not only of your academic backgrounds but also teaching and research experience, publications, presentations, awards, honors and other details.

WRITING

1. **Write a CV for your possible part-time job (say what it is). Think of the necessary skills, qualifications and experience for this job.**
2. **With the partner exchange your CVs and check out if your CVs follow the rules of CV writing.**
3. **Complete a Cover letter to apply for the part-time job of your choice.**

Your address
and the date

6345 Willow Avenue
Baltimore, Mariland
21220

4 November 20...

Name and address of the company/person you are writing to

Mr. Charles H.C. Wright
City Hall
Special Projects Officer
19 Harbor Place
Baltimore, Mariland 21220

Salutation
If you know the name of the person, put it:
Dear Mrs. Wright
Dear Ms. Wright
Dear Mr. Wright
If not, put:
Dear Sir(s), Madam

Dear Mr. Wright,

The body of the letter

Paragraph 1
The introduction
- *reason for writing*

I am writing to apply for the position of _____ which was advertised on the Career Search web site on September 7th.

Paragraph 2
The message
- *education and qualifications*

I am a student of _____, now in my second year (fourth semester) at the _____.

Paragraph 3
- *work experience or present job*

As part of the course of studies all students are required to do an 8-month /a 6-week/ work placement. I am very _____ in the job and I think that I have many of the necessary _____.

Paragraph 4
- *other details (e.g. interests)*

I _____.

I am good at _____.

I have _____ and I have worked as a _____.

I am highly motivated, hard-working and _____.

Paragraph 5
- *availability for interview*

I would be very grateful if you could let me know whether there would be a place for me. I would appreciate the opportunity of a new challenge.

Please find enclosed my CV and details of my courses. As you can see from my particulars, I have a good command of English and a working knowledge of German.

I look forward to hearing from you soon. Please let me know if you need more information.

If you start: *Dear Sir,*
Finish: *Yours faithfully*
If you start:
Dear Mr. Wright
Finish: *Yours sincerely*

Yours sincerely,

(your signature)
(your name and surname)

4. **Work in pairs. Exchange your letters and analyze them to decide if the letter of your fellow student provides complete information. Make some suggestions for improvements if necessary.**

LISTENING

1. **Before you listen answer the questions.**

- Have you ever applied for a job? What was the job?
- Did you get the job? Why?/Why not?
- Did you have an interview with a Personnel Officer?
- What questions were you asked during the interview?

2. **Brian Saunders has come for an interview to apply for a job. Listen to the interview and complete the chart. Is he likely to get the job? Why?/Why not?**

the job title	previous experience & duties	personal qualities	plans for the future	working hours	salary
……..	*part-timer in a ……* *maintained scientific equipment* …… ……	…… …… *enjoys working in a team*	…… …… *technical writing*	…… ……	…… ……

Discuss

- Why previous experience is preferable or even important for getting a job?
- How can you gain necessary experience and skills while you are still a student?
- Are there Career Center Services at your faculty? How do graduates from your faculty find jobs? Where do they usually work?

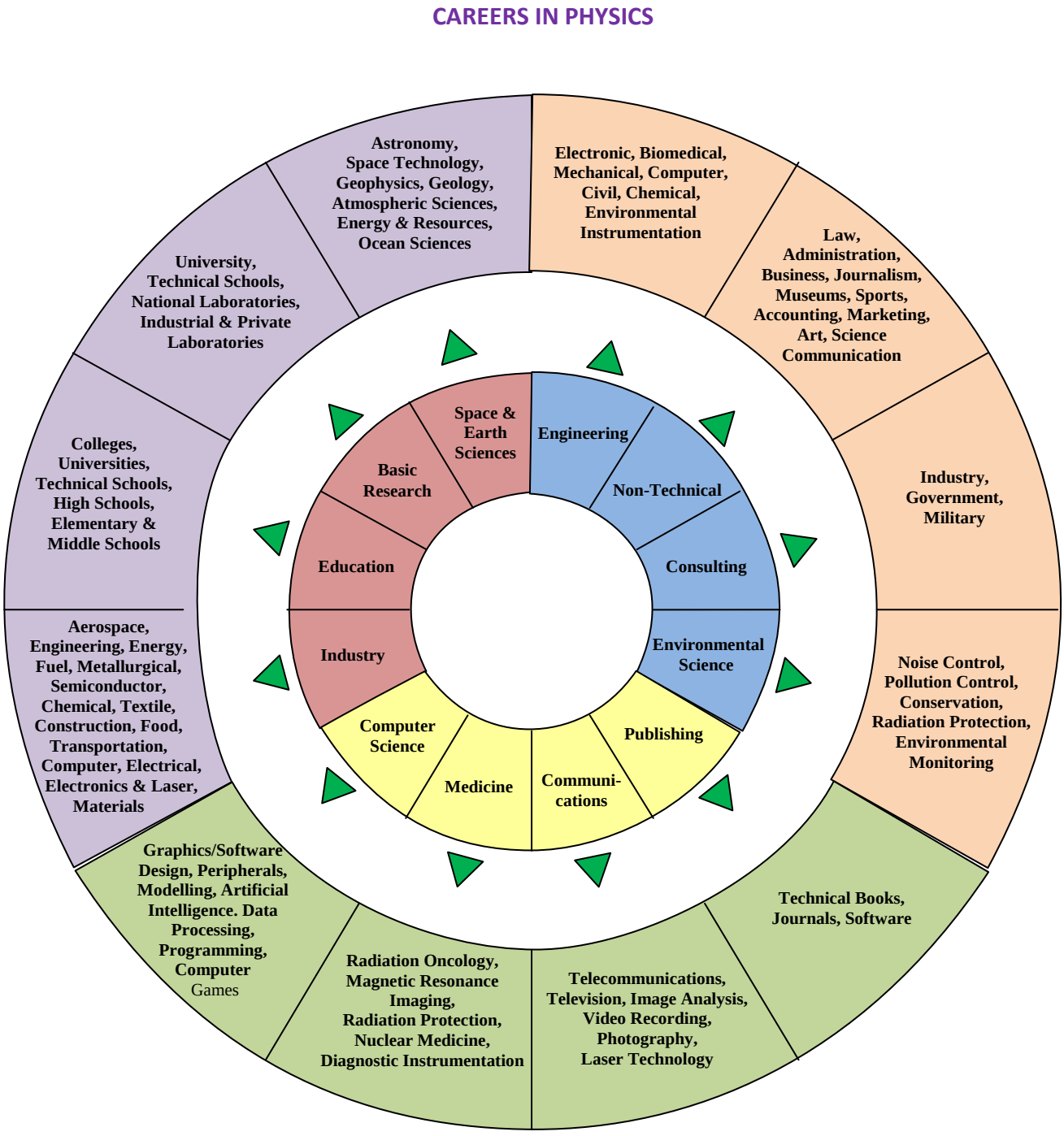
Get real

Google for *JOB ZONE 5* website to find out about different jobs for physics graduates.
Choose any physics related occupation and read its description. Prepare to give a talk about this job.
Follow the guidelines:

- ✓ **Name of the job**
- ✓ **Duties involved**
- ✓ **Skills and qualifications**
- ✓ **Personal qualities**
- ✓ **Job Conditions**

WRITING

1. **Study the mind-map illustrating the employment opportunities for physics graduates. What are the most attractive fields/areas for you?**



2. **Write an essay of about 150 words to describe the diagram. Make use of the model and *Functional language* box on *page 148*.**

Example:

As can be seen in the diagram, physics offers challenging, exciting and productive careers. To begin with, as a career, physics covers many specialized fields – from telecommunications, electronics and astrophysics to medical physics and …

Obviously, physics offers a variety of employment opportunities. For instance, you can take a job of consulting engineer, researcher, … as well as … and …

Another point to remember is that …

Functional language	***Linking words and phrases***
Firstly/In the first place/To begin with…	In fact/Actually…
Secondly/A second area to consider is…	In general/On the whole, …
For instance/For example, …	Clearly/Obviously, ….
Another point to remember is…	Alternatively/Another possibility is…
As well as/In addition to/What is more…	Especially/Particularly/Chiefly/Mainly/Mostly
On the one hand/On the other hand…	However, …
Finally, …	Not only … but also…
In conclusion, …	Similarly/In the same way…
Last but not least, …	In other words/That is to say, …
Taking all points into consideration, …	In relation to/Regarding…
	Thus we can see that…

Summarizing

1. **Read the text «Профессии будущего?» and highlight the Russian equivalents to the English word combinations (1-11).**

1) to be in the vanguard of the 21st century jobs/professions
2) according to specialists' forecasts
3) industrial production
4) to be of value/high priority
5) a combination of training in engineering and economics/law
6) hardware design engineers
7) to be in demand
8) to promise/guarantee financial support
9) superstrong implants
10) wear-resistant alloys & rust-preventing paints
11) at the frontier of electronics and biotechnology

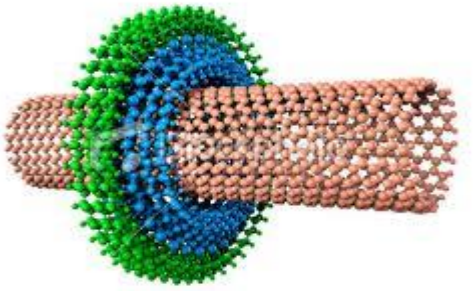
Add new vocabulary to your vocabulary notebook. ✍

Профессии будущего?

Престижность профессий меняется со временем. Какие же специальности окажутся на гребне волны в XXI веке?

По прогнозам специалистов на лидирующие позиции выйдут инженерные специальности, связанные с промышленным производством. Особенно будет цениться сочетание технического и экономического или юридического образования, знание английского или любого другого европейского языка.

Далее следуют IT специалисты, а именно, разработчики компьютерного аппаратного обеспечения. В наши дни веб-дизайнер - одна из самых высокооплачиваемых «компьютерных» профессий.



По прогнозам, также будут востребованы все специальности, связанные с нанотехнологиями. Этой отрасли на ближайшие десятилетие обещана активная поддержка и финансирование. К настоящему времени, открыты и познаны еще далеко не все нановозможности, однако инновационные технологии с использованием наночастиц уже сейчас позволяют делать сверхпрочные имплантаты, особо износоустойчивые сплавы и краски. И это только начало! Уже ясно, что нанотехнологии охватят все сферы: машиностроение, космические технологии, пищевую промышленность, медицину и т.д.

Все большую важность будут приобретать специальности на стыке электроники и биотехнологий, которые требуют от специалиста глубоких знаний, как в электронике, так и в биоинженерии. Вполне вероятно, что рабочие биочипы - дело весьма недалекого будущего.

Конечно же, это далеко не весь список популярных и наиболее востребованных профессий будущего. Так что, может быть стоит задуматься о профессии космического гида, сопровождающего космических туристов на другие планеты и в другие Галактики в отпуск или даже на ПМЖ?

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

In the Realm of Jobs

Here are the lists of verbs and adjectives you might need to speak about your job.

A. To express responsibilities and tasks to be performed:

- **to analyze**
- **to apply**
- **to arrange**
- **to assist**
- **to classify**
- **to compute**
- **to consult**
- **to create**
- **to edit**
- **to design**
- **to develop**
- **to evaluate**
- **to examine**
- **to explore**
- **to identify**
- **to improve**
- **to install**
- **to investigate**
- **to maintain**
- **to operate**
- **to organize**
- **to perform**
- **to plan**
- **to prepare**
- **to present**
- **to programme**
- **to repair**
- **to report**
- **to solve**
- **to systematize**
- **to test**
- **to update**
- **to verify**

B. To describe your qualities:

- **active**
- **adaptable**
- **cooperative**
- **creative**
- **dedicated**
- **determined**
- **efficient**
- **energetic**
- **enthusiastic**
- **independent**
- **innovative**
- **loyal**
- **methodical**
- **motivated**
- **organized**
- **persistent**
- **positive**
- **reliable**
- **resourceful**
- **responsible**
- **self disciplined**
- **self-motivated**
- **thoughtful**
- **willing to learn**

C. Words and phrases you use to describe and explain your skills:

Experience • Extensive academic/practical background in… • Experienced in all aspects of… • Knowledge of/experienced as/proficient in… • Provided technical assistance to…	**Responsibilities** • In charge of… • Supervised/coordinated... • Familiar with… • Assigned to…
Ability • Trained in… • Expert at… • Working knowledge of… • Coordinated… • Organised…	**Roles** • Analysed/evaluated… • Established/created/designed… • Formulated… • Managed… • Presented…
Success • Succeeded in… • Experience involved/included… • Achieved… • Instrumental in...	**Personal attributes** • Committed to… • Confident… • Enthusiastic user of… • Actively sought…

Progress Monitoring

In this Unit you have worked on the vocabulary related to the topic "Jobs and Career Options for Physicists".

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

1. to pursue an academic/research career
2. to be in the mainstream
3. to remain in touch with the scientific community
4. to require special training/skills/qualifications/ personal qualities
5. to work on state of the art, team oriented projects
6. to broaden one's knowledge
7. to have experience and training in sth
8. to apply for a job
9. to stand sb in good stead
10. to write a CV/Cover letter
11. a well/best/highest-paid job
12. to have (no) shortage of skills
13 to keep up to date with sth
14 to be well-organized/self-confident/careful/ hard-working/active/creative/responsible
15. to be in demand
16. to gain necessary experience and skills
17. job responsibilities/duties
18. to have relevant skills
19. to get a job with high/acceptable salary
20. to go for a job interview

Progress Test

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

a) job, option, career, work
b) training, experience, degree, qualification
c) choice, option, opportunity, decision
d) to develop, to utilize, to design, to create
e) well-organized, well-paid, self-confident, hard-working
f) interview, CV, cover letter, resume

2. Give English equivalents to these Russian word combinations.

a) престижная работа/профессия
b) прогнозы специалистов
c) быть на гребне волны
d) пользоваться спросом
e) устраиваться на работу

f) превосходить к-л., выделяться

g) избрать своей профессией

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

e.g. [kə'rɪə] - career – карьера

a) [ɪn'hɑ:n(t)smənt]

b) ['kwɔlɪfaɪd]

c) [pə'sju:]

d) [ˌpɜ:s(ə)'nel 'ɔfɪsə]

e) [kəˌrɪkjələm 'vi:taɪ/ 'vaɪti:]

f) ['rezjumeɪ]

g) [ə'veɪləbl]

4. Put the verbs in brackets into the correct *infinitive* or the *-ing* form.

a) They were trying *(persuade)* him to change his mind.

b) He regrets *(pretend)* to follow the lab safety instructions.

c) You seem (know) this formula well. Would you mind *(illustrate)* how it can be applied in these calculations?

d) I regret *(tell)* you that you have failed *(solve)* this equation.

e) I wanted *(verify)* the results I got during the experiment.

f) She arranged *(meet)* with her tutor.

g) If nothing else works try *(read)* the instructions.

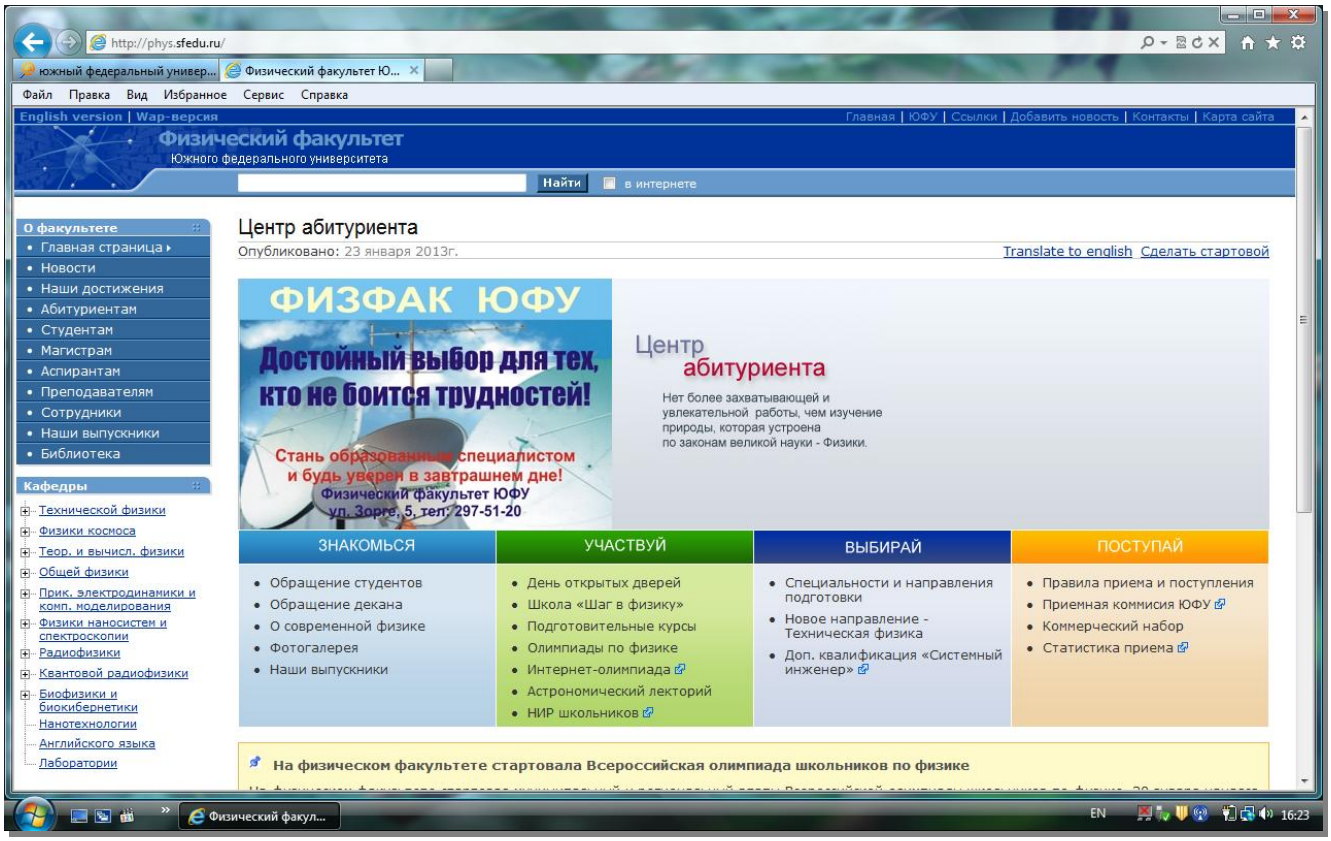
h) He advised me *(search)* career websites for more information on the jobs available with my major.

i) Working in a team means *(share)* success as well as responsibility if something goes wrong.

j) He offered *(test)* my model on a more powerful computer.

CONSOLIDATION

Project Work



Any university looks for efficient ways to encourage more school-leavers to apply to its faculties.
The faculty of physics at your university has decided to create a video clip for its website.
The faculty students are invited to participate and shoot a film about each department of the faculty.

Work in small groups. Decide on the department you would like to make your film about.
Make sure you include information about:

- **the significance of this field of physics**
- **a brief the history & academic traditions of the department**
- **major research trends, leading scientists & their achievements**
- **degree programmes & learning facilities**
- **career outlook for the graduates in this field**

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