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АНГЛИЙСКИЙ ЯЗЫК ДЛЯ ИНЖЕНЕРОВ ENGLISH FOR ENGINEERS

УЧЕБНИК И ПРАКТИКУМ ДЛЯ СПО

Рекомендовано Учебно-методическим отделом среднего профессионального образования в качестве учебника для студентов образовательных учреждений среднего профессионального образования

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Целью учебника является формирование и развитие компетенций, необходимых для использования английского языка в сфере профессионального общения. Учебник позволяет развить навыки коммуникативного чтения научной литературы, устной и письменной научной речи, расширить словарный запас за счет общенаучной и специальной лексики, отработать характерные для научного текста грамматические явления английского языка. В учебнике содержатся оригинальные научные и научно-популярные тексты, способствующие расширению кругозора обучающихся.

Данный учебник предназначен для студентов инженерно-технических специальностей со средним (Intermediate) уровнем владения английским языком (что соответствует уровню B1 по Общеввропейской шкале определения уровня владения языком), обучающихся в образовательных учреждениях среднего профессионального образования.

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Предисловие

Учебник “English for Engineers” может быть рекомендован студентам инженерно-технических специальностей со средним уровнем знаний английского языка. Учебник имеет целью развить у студентов навыки чтения, устной речи и письма на материале оригинальной английской и американской научной литературы.

В ходе работы с учебником решаются следующие задачи:

1) отрабатываются навыки произношения и чтения общенаучной и терминологической лексики, интонационное оформление смысловых групп, предложений, абзацев и текста в целом;

2) прорабатываются грамматические явления, характерные для научного стиля изложения;

3) активизируются наиболее употребительные общенаучные и терминологические лексические единицы;

4) формируются навыки дифференцированного чтения научной литературы с целью извлечения информации;

5) развиваются навыки перевода текстов по специальности;

6) формируются навыки реферирования и аннотирования научной статьи;

7) формируется готовность принять участие в обсуждении профессиональных вопросов;

8) осуществляется знакомство с функционально-стилистической неоднородностью научной речи.

В результате освоения материала учебника студент должен:

знать лексический и грамматический материал, изложенный в учебнике;

уметь читать на английском языке литературу по специальности с целью поиска профессионально значимой информации; переводить тексты широкого профиля по специальности; вести беседу научной направленности; читать

на английском языке формулы и описывать графики; делать доклады и презентации;

владеть изучаемым языком в целях его практического использования в профессиональной и научной деятельности не ниже уровня B1.

Учебник содержит **пять уроков**, каждый из которых рассчитан на 14 аудиторных часов и состоит из текстов, лексического и грамматического разделов и упражнений. Типы упражнений подобраны таким образом, чтобы способствовать эффективному развитию основных видов речевой деятельности, включая навыки перевода.

Предусматриваются следующие виды работы:

- восприятие и воспроизведение слов, словосочетаний и предложений с отработкой интонации;
- чтение вслух фрагментов текста с соблюдением правильной ритмики и интонации;
- нахождение правильных лексических и грамматических эквивалентов в двух языках при переводе;
- создание собственных предложений или связного текста с использованием ключевых слов и выражений;
- вопросно-ответная форма работы с текстом;
- составление плана или семантической карты прочитанного текста с последующим его пересказом;
- структурно-семантический анализ абзаца;
- смысловой анализ текста по абзацам;
- упражнения на перифраз;
- обучение навыкам «сжатых» пересказов и письменной компрессии текстов и др.

Тексты к учебнику отобраны из аутентичных современных научных и научно-популярных изданий и дают представление о жанровом многообразии стиля научного изложения. В учебник вошли отрывки из лекций, монографий, учебников, статей и книг англоязычных авторов. Кроме того, студентам предлагаются отрывки из научно-популярной книги известного русского астрофизика Игоря Новикова, вышедшей в издательстве Cambridge University Press.

Учебник имеет **три приложения**, включающие указатель слов из раздела Active Vocabulary, список химических элементов, ключи и ответы к некоторым заданиям.

Работа с учебником направлена на усвоение следующих лингвистических, когнитивных и коммуникативных компетенций.

Урок 1

знать: лексический и грамматический материал урока;

уметь: читать научный текст вслух с соблюдением правильной ритмики и интонации; читать и понимать несложные научные тексты; составлять вопросы к тексту; отвечать на вопросы по содержанию прочитанного; читать формулы и описывать геометрические фигуры; обсуждать вопросы, связанные с тематикой урока;

владеть: произносительными и ритмико-интонационными навыками; навыками чтения научного текста с целью извлечения информации; навыками представления невербальной информации вербальными средствами.

Урок 2

знать: лексический и грамматический материал урока;

уметь: читать и понимать научные тексты различной жанровой принадлежности; письменно переводить небольшие фрагменты статьи и монографии с английского языка на русский; составлять план прочитанного текста и пересказывать его с опорой на план; устно переводить несложный текст с листа, опираясь на изученную лексику и распознавая значение незнакомых слов по контексту; описывать таблицы; решать и составлять задачи по физике на английском языке; обсуждать вопросы и делать сообщения по тематике урока;

владеть: навыками чтения с целью извлечения информации; навыками чтения и перевода несложного научного текста; навыками устного монологического высказывания на заданную тему.

Урок 3

знать: лексический и грамматический материал урока;

уметь: читать, понимать и пересказывать научные тексты разной степени сложности; анализировать, сопоставлять и обобщать полученную из текстов информацию на английском языке; аргументированно излагать свою точку зрения; выделять ключевые предложения в составе абзаца; разбивать текст на абзацы; формулировать главную идею текста; обсуждать вопросы и делать сообщения по тематике урока;

владеть: различными видами коммуникативного чтения; навыками краткого пересказа текста; навыками реферирования; навыками критического мышления.

Урок 4

знать: лексический и грамматический материал урока;

уметь: читать и понимать тексты большей степени сложности; выборочно извлекать информацию из текста; выражать одну и ту же мысль разными языковыми средствами; распознавать значение слов по контексту; находить правильные лексические и грамматические эквиваленты в английском и русском языках при переводе; делать сообщения по тематике урока; аргументированно излагать свою точку зрения во время дискуссии;

владеть: навыками коммуникативного чтения; навыками компрессии текстов; навыками ведения дискуссии; навыками критического мышления.

Урок 5

знать: лексический и грамматический материал урока;

уметь: читать текст с полным пониманием содержания; проводить структурно-семантический анализ абзаца; формулировать главную идею текста и абзаца; выражать одну и ту же мысль разными языковыми средствами; составлять семантическую карту; кратко излагать на письме суть прочитанного; читать самостоятельно большие по объему тексты, используя полученную информацию как в устно-речевом общении, так и при создании письменного речевого произведения; делать публичные выступления; описывать графики и диаграммы; использовать средства наглядности; аргументировать свою точку зрения; участвовать в дискуссии;

владеть: навыками интенсивного и экстенсивного чтения; навыками критического чтения; навыками реферирования; презентационными навыками; навыками академического письма; навыками критического мышления.

Методические рекомендации

В основу учебника положен тематический принцип организации текстового материала. Каждый урок содержит объединенные общей темой научные тексты для чтения и обсуждения. Для снятия трудностей восприятия тексты снабжены списком незнакомых слов и выражений.

Работа с текстом начинается с фонетических упражнений и заданий, стимулирующих интерес студентов к содержанию текста. Послетекстовые упражнения направлены на разви-

тие умений отделить главное от второстепенного, на передачу содержания текста в виде устного или письменного изложения и др. Заметим, что при чтении текстов следует добиваться понимания содержания беспереводным путем, например, с помощью вопросно-ответных упражнений. Целесообразно акцентировать внимание лишь на наиболее трудных с точки зрения лексики и грамматики случаях. При работе с текстами рекомендуется развивать навыки чтения вслух, в процессе которого контролируются произносительные и ритмико-интонационные навыки. Удельный вес этого вида чтения может меняться в зависимости от того, в какой степени студенты владеют техникой чтения.

Развитие навыков различных видов коммуникативного чтения является одной из основных целей учебника. Просмотровое чтение (Scanning), чтение с пониманием основного содержания (Skimming), как правило, предшествуют изучающему чтению — чтению с полным пониманием текста (Reading for Detailed Comprehension). Ясно, что точное понимание прочитанного предполагает знание лингвистических особенностей иностранного языка, умение анализировать текст, понимать его на уровне значения и смысла. Для формирования этих умений требуется изучение языковой системы, ее лексических и грамматических особенностей. Проработка лексических и грамматических аспектов осуществляется в разделах Active Vocabulary и Grammar Focus.

Раздел Active Vocabulary имеет своей целью расширение словарного запаса студентов на базе выделенных из основного текста наиболее часто встречающихся общенаучных слов и образованных на их основе словосочетаний. При работе с лексическим материалом используется методика двустороннего перевода, что позволяет студентам устанавливать соответствие между русским и английским языками. Нахождение лексических эквивалентов происходит как на уровне словосочетаний, так и на уровне предложений, не содержащих грамматических трудностей. Знание минимального лексико-грамматического контекста общенаучных слов позволяет студентам продуцировать собственную речь. Эффективным способом проверки степени сформированности навыка речепорождения является задание передать содержание русского текста на английском языке.

Грамматический раздел (Grammar Focus) имеет целью обратить внимание студентов на наиболее актуальные для научного регистра явления английской грамматики. Грамма-

тический материал представлен в сжатой форме, преимущественно в виде таблиц, и закрепляется в процессе выполнения различных заданий и упражнений. В тех случаях, когда отдельные студенты испытывают недостаток информации по тем или иным грамматическим темам, рекомендуется отсылать их к другим пособиям по грамматике для самостоятельной проработки.

Важным видом работы являются упражнения на перекодирование информации из невербальной формы в вербальную и наоборот. Задания описать на английском языке геометрические фигуры, формулы, графики и т.д. могут выполняться в парах или группах и призваны способствовать развитию всех видов речевой деятельности.

В учебнике имеются упражнения, направленные на развитие навыков продуктивной письменной речи, а именно: составление резюме, конспекта, плана письменного или устного высказывания и т.д. Широкое применение письменных работ должно способствовать формированию грамотности речи, как письменной, так и устной.

Упражнения на базе текстов, словаря и грамматического материала рекомендуется выполнять в произвольном порядке по усмотрению преподавателя.

Тексты под заголовком *Supplementary Material for Reading and Discussion* и задачи из раздела *Physics Problems for Fun* предлагается использовать для самостоятельного чтения с последующим обсуждением в аудитории.

В конце учебника приводится подобранный в соответствии с тематикой уроков список видео интернет-ресурсов, которые позволят студентам развить и усовершенствовать навыки восприятия научной речи «на слух».

Unit I

OVERVIEW OF PHYSICS

Grammar	Word Order. Sentence Forms. Types of Questions. Review of Tenses: Active Forms.
Skills	Reading and Speaking. Information Transfer: Formulae Reading. Describing Size and Shape

1. As you read the text follow the stress, rhythm and intonation pattern used by the speaker.

A typical short dictionary definition says that physics is a branch of science that deals with matter, energy, and their interactions. This is vague and general enough to include what is usually considered to be chemistry; in any case, it does not give any real feeling for what is involved. Longer dictionary entries usually expand the definition by noting that physics includes subfields such as mechanics, heat, electricity, and so forth. They give no clues as to why some subfields of science are included and others are not.

vague — расплывчатый

entry — статья

clue — ключ

A better approach to defining physics is to ask what physicists are concerned about. Physicists attempt to understand the basic rules or laws that govern the operation of the natural world in which we live. Since their activities and interests evolve with time, the basic science called physics also changes with time.

approach (n) — подход

evolve — развиваться

Many of the most active contemporary subfields of physics were undreamed of a generation or two ago. On the other hand, some parts of what are now considered to be chemistry or engineering were once considered to be physics. This is because physicists sometimes gradually abandon a field once the basic principles are known, leaving further developments and practical applications to others.

generation — поколение

abandon — оставлять

The fact that physics deals with the basic rules governing how the world works lets us see why people with varied interests may find the study of physics interesting and useful. For example, a historian who wants to understand the origin of our contemporary society will find significance in the story of the development of physics and its relationship to other human activities. Similarly, a philosopher concerned about concepts of space and time will profit greatly from understanding the revolutionary twentieth-century advances in physics.

deal with (*v*) — иметь дело с
varied — разнообразный
origin — происхождение
similarly — аналогично
profit (*v*) — извлекать пользу

An obvious impact of physics on both the life and physical sciences is in the area of instrumentation. Physical principles underlie the operation of light and electron microscopes, of X-ray machines and nuclear magnetic resonance spectrometers. Physics is also fundamental to a true understanding of chemistry, biology, and the earth sciences. The physical laws governing the behavior of molecules, atoms, and nuclei are the basis for all chemistry and biochemistry. At the macroscopic level, the effects of forces of various types strongly influence the shapes of anatomical and human-built structures. Physiology offers many examples of physical processes and principles; diffusion within cells, the regulation of body temperature and the electrical signals in nerves are just a few. In exercise science, activities ranging from running and jumping to karate can be analyzed and sometimes optimized by the application of physical principles.

obvious — очевидный
impact (*n*) — влияние
underlie — лежать в основе

cell — клетка

(from *General Physics* by M.M. Sternheim, J.W. Kane)

2. Practise reading the following words.

type [taɪp]

typical ['tɪpɪkl]

vague [veɪɡ]

chemistry ['kemɪstri]

various ['vɛəriəs]

varied ['vɛəriəd]

historian [hɪ'stɔːriən]

origin ['ɒrɪdʒɪn]

mechanics [mɪ'kæniks]
 law [lɔ:]
 govern ['gʌvn]
 natural ['nætʃ(ə)rəl]
 abandon [ə'bændən]
 biology [baɪ'ɒlədʒɪ]
 concept ['kɒnsept]
 physiology [ˌfɪzɪ'ɒlədʒɪ]
 nuclear ['nju:kliə]
 nuclei ['nju:kliəɪ]
 resonance ['rez(ə)nəns]

obvious ['ɒvviəs]
 society [sə'saɪəti]
 similarly ['sɪmələli]
 impact ['ɪmpækt]
 area ['ɛəriə]
 electron [ɪ'lektrɒn]
 microscope ['maɪkrəskəʊp]
 effect [ɪ'fekt]
 molecule ['mɒlɪkjʊ:l]
 spectrometer [spek'trɒmɪtə]
 earth [ɜ:θ]
 karate [kə'reɪti]

3. Practise reading the following word combinations. Give their Russian equivalents. Try to remember the context in which these word combinations are used.

a typical definition, a branch of science, deal with matter, a dictionary entry, give a clue, basic rules and laws, the natural world, contemporary subfields of physics, further developments, practical applications, varied interests, the study of physics, human activities, the revolutionary twentieth-century advances in physics, an obvious impact of physics, the area of instrumentation, light and electron microscopes, X-ray machines, nuclear magnetic resonance, earth sciences, the macroscopic level, the effects of forces of various types, the application of physical principles

4. Practise reading the first two paragraphs of the text. Use the upward intonation before a one-unit pause to show that the idea is not completed and continuation is implied; the falling intonation may be used to attach more importance to what is being said. Let your voice go down at the end of the sentences.

A typical short dictionary definition says | that physics is a branch of science | that deals with matter, | energy, | and their interactions. || This is vague and general enough | to include what is usually considered to be chemistry; | in any case, | it does not give any real feeling for what is involved. || Longer dictionary entries | usually expand the definition by noting | that physics includes subfields | such as mechanics, | heat, | electricity, | and so forth. || They give no clues | as to why | some subfields of science are included | and others are not. ||

A better approach to defining physics | is to ask | what physicists are concerned about. || Physicists attempt to understand the

basic rules | or laws | that govern the operation of the natural world | in which we live. || Since their activities and interests evolve with time, | the basic science | called physics | also changes with time. || Many of the most active contemporary subfields of physics | were undreamed of | a generation or two ago. || On the other hand, | some parts of what are now considered to be chemistry | or engineering | were once considered to be physics. || This is | because physicists sometimes gradually abandon a field | once the basic principles are known, | leaving further developments | and practical applications to others. ||

5. Intone the remaining two paragraphs of the text and read them.

The fact that physics deals with the basic rules governing how the world works lets us see why people with varied interests may find the study of physics interesting and useful. For example, a historian who wants to understand the origins of our contemporary society will find significance in the story of the development of physics and its relationship to other human activities. Similarly, a philosopher concerned about concepts of space and time will profit greatly from understanding the revolutionary twentieth-century advances in physics.

An obvious impact of physics on both the life and physical sciences is in the area of instrumentation. Physical principles underlie the operation of light and electron microscopes, of X-ray machines and nuclear magnetic resonance spectrometers. Physics is also fundamental to a true understanding of chemistry, biology, and the earth sciences. The physical laws governing the behavior of molecules, atoms, and nuclei are the basis for all chemistry and biochemistry. At the macroscopic level, the effects of forces of various types strongly influence the shapes of astronomical and human-built structures. Physiology offers many examples of physical processes and principles; diffusion within cells, the regulation of body temperature and the electrical signals in nerves are just a few. In exercise science, activities ranging from running and jumping to karate can be analyzed and sometimes optimized by the application of physical principles.

6. Entitle the text.

7. Answer the questions on the text.

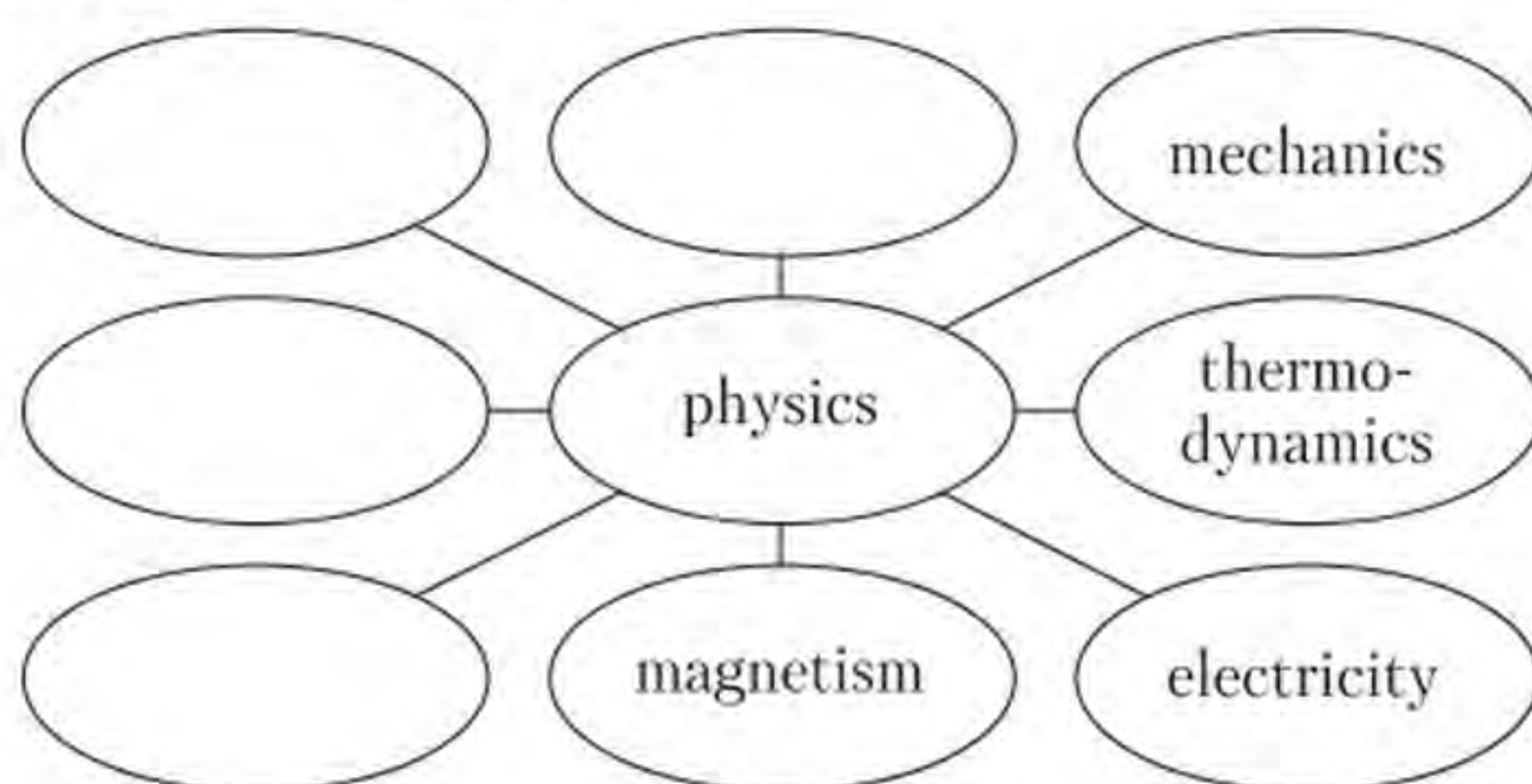
1. What does physics deal with?
2. Why do some definitions of physics seem inadequate?
3. What do physicists attempt to understand?
4. Why do physicists sometimes abandon a field of research?

5. Why are people with varied interests attracted to studying physics?
6. What is the impact of physics on life?
7. What is the relation of physics to other sciences?
8. **Retell the text.**

9. **Match these subfields of physics to their areas of study.**

- | | |
|-------------------|--|
| 1. magnetism | a. relationship between heat and other forms of energy |
| 2. thermodynamics | b. the phenomenon of electric charge |
| 3. mechanics | c. the effect of forces on bodies |
| 4. electricity | d. magnets and effects of magnetic fields |

10. **Name some other subfields of physics and define them. Complete the chart below.**



Vocabulary Work

Introduction to General Scientific Lexis (GSL)

1. **Take a close look at the language of research and discovery which can be effectively used in your professional activity. Pay attention to how the key words are explained and memorise them.**

Science and scientists

Science is the study of the nature and behaviour of natural things and knowledge obtained about them.

obtain — получать

Scientific describes words that relate to science.

A **scientist** is someone who works in science.

Technology and technologists

Technology describes scientific knowledge applied for practical purposes.

Technological describes things relating to technology.

Technologists are researchers who work in a particular area of technology.

apply — применять,
прилагать
technology — техни-
ка, технология
particular — особен-
ный, отдельный

Innovation

Innovation is the act of thinking of new ideas, developments, and improvements.

These are **innovations** and the people **innovating** them are **innovators**. The related adjective is **innovative**.

The first, **experimental**, versions of a new technological idea are **prototypes** (e.g. a prototype version).

innovation — ново-
введение, изобре-
тение
development — раз-
витие, совершенство-
вание, разработка
prototype — про-
тотип, опытный
образец

Inventors

Invention or **inventiveness** is the ability to design new machines, devices, or products.

An **invention** is a new machine, device, or product.

People who invent things are **inventors**. The related adjective is **inventive**.

invent — изобретать
design (v) — проек-
тировать; предназна-
чать(ся)

Researchers

People trying to find facts about something, **study** it or do **research** in it, into it, or on it.

A piece of research may be referred to as a **study** or a **research study**. These terms also refer to the published results of the research.

Scientific research often takes place in **laboratories**, or labs. There are also **research laboratories** or research labs.

People doing research are **researchers**. Research as a noun is usually but not always an uncountable noun.

research (n) — ис-
следование, поиск
refer (to) — упоми-
нать; относиться (к);
ссылаться (на)
to be referred to as —
называться

uncountable noun —
неисчисляемое суще-
ствительное

Experimentation

Experiments are scientific tests that are **carried out, conducted, done, or performed** to see what happens to something in particular conditions.

A **field experiment** is one done in real surroundings and not in a laboratory.

A **thought experiment** is done by thinking about a problem, rather than experimenting on it.

Doing experiments is **experimentation**, the people who do them are **experimenters**.

Experimental approaches

A table used for conducting experiments is a **laboratory bench**. A **test tube** is a small tube-shaped container used in experiments.

Experiments may be conducted on **samples** or **specimens**.

The **validity**, or reality, of experimental results is tested by repeating the experiments to see if the results obtained are the same.

Observation and hypothesis

A **phenomenon** is something that is seen to occur or exist: it is **observed**.

Information obtained by making **observations** and making **measurements** of them is **data**.

Data is **collected** or **gathered**. It is then **processed** and analysed in a process of **analysis**. Unprocessed, unanalysed data is **raw data**.

Scientists look for meaning in data: they interpret it in order to reach conclusions or to conclude things.

Data and other information form the evidence for these conclusions.

The form **data** can be used as a singular or plural.

Sometimes **datum** is used for the singular.

An experiment may be done **to test a hypothesis**: to see whether a suggested explanation for something is true.

carry out — проводить

condition — условие
surroundings — обстановка, среда, окружение
rather than — а не

approach (*n*) — подход, метод

sample — образец, проба

specimen — образец, пробный экземпляр

validity — достоверность, правильность, обоснованность

obtain — получать

occur — происходить, случаться

observe — наблюдать

process (*v*) — обрабатывать

raw — сырой, необработанный

reach a conclusion — прийти к выводу

evidence — признак, данные; доказательство

Approaching scientific problems **by hypothesizing** about them and testing these hypotheses by observation and **experimentation** is often described as being **empirical**. approach a problem — решать задачу

Discoveries and breakthroughs

The **discoverer** of something is the person who finds it or becomes aware of it for the first time by **discovering** it or by **making a discovery**. breakthrough — прорыв; важное научное открытие; техническое достижение

A discovery may be described as a **breakthrough**. People may say that it is **ground-breaking** or that it **breaks new ground**. ground-breaking — передовой

Scientists who are the first to do work in a principal area are **pioneers**. They are said to **pioneer** particular developments or do **pioneering work** in a particular area. pioneer (v) — выполнять впервые

Theory and theorists

A **theory** is an idea or set of ideas designed to explain something. The related adjective is **theoretical**. People who produce and work on theories are **theorists** or **theoreticians**. set (n) — комплект; набор; ряд, серия

A **model** of a phenomenon, system, or process is a theoretical description of it, designed to aid understanding of how it works. aid (v) — помогать

Theory is also used as an uncountable noun to talk about the theories of a particular area as a whole.

as a whole — в целом

Scientists **model** phenomena, systems, and processes, for example on a computer.

Laws of science

A statement in mathematics or logic that is the product of reasoning is a **theorem**. The explanation of this reasoning is the theorem's **proof**, often in the form of a series of **equations**. statement — утверждение, формулировка
reasoning — рассуждение

A **formula** is a series of mathematical, chemical, or other symbols that express a scientific rule. equation — уравнение

General statements that are confirmed by observations are **principles** and **laws**. confirm — подтверждать

Theorems, principles, and laws are often preceded by the name of the person who first **formulated** them, e.g. the Copernican principle.

Reasoning

If you **deduce** or **infer** something, you can come to the conclusion that it is true. deduce — выводить (формулу)

Deduction or **inference** can refer to a conclusion and to the process of reaching it. infer — заключать, подразумевать
Reasoning like this is deductive in its **logic** and may be described as **logical**. inference — вывод, заключение

Presenting findings

Scientists usually **publish** their **results** or **findings** in **articles** or **papers** in scientific **journals**. findings — результаты
paper — доклад, статья

Articles and papers are **submitted** to journals for assessment before **publication**. submit — представлять
assessment — оценка

Scientists may give presentations of their work at **conferences** or **congresses**: gatherings of scientists who meet to discuss their work. These and other types of scientific gatherings are referred to as **meetings**. presentation — изложение, представление, выступление
meeting — заседание, собрание, встреча

If someone **delivers**, **gives** or **presents** a **paper** at a meeting such as this, they make an oral presentation.

A scientist presents **findings** to a conference on something, delivers a paper at a **meeting**, or gives a paper on something at an international **congress**. deliver a paper — делать доклад

(from *Key Words in Science and Technology* by B. Mascull)

2. Spell the following words in your notebooks. Practise reading them.

[haɪ'pəθəsis]

['eɪd(ə)ns]

[ɪm'pɪrɪkl]

[dɪ'dʒu:s]

[ɪn'fɜ:]

['ɪnfərəns]

['prəʊsɪs]

[lɔ:]

['spesɪmən]

['breɪkθru:]

['prəʊtətaɪp]

['pɜ:pəs]

[rɪ'sɜ:tʃ]

['nɒlɪdʒ]

[ə'kɜ:]

[prɪ'si:d]

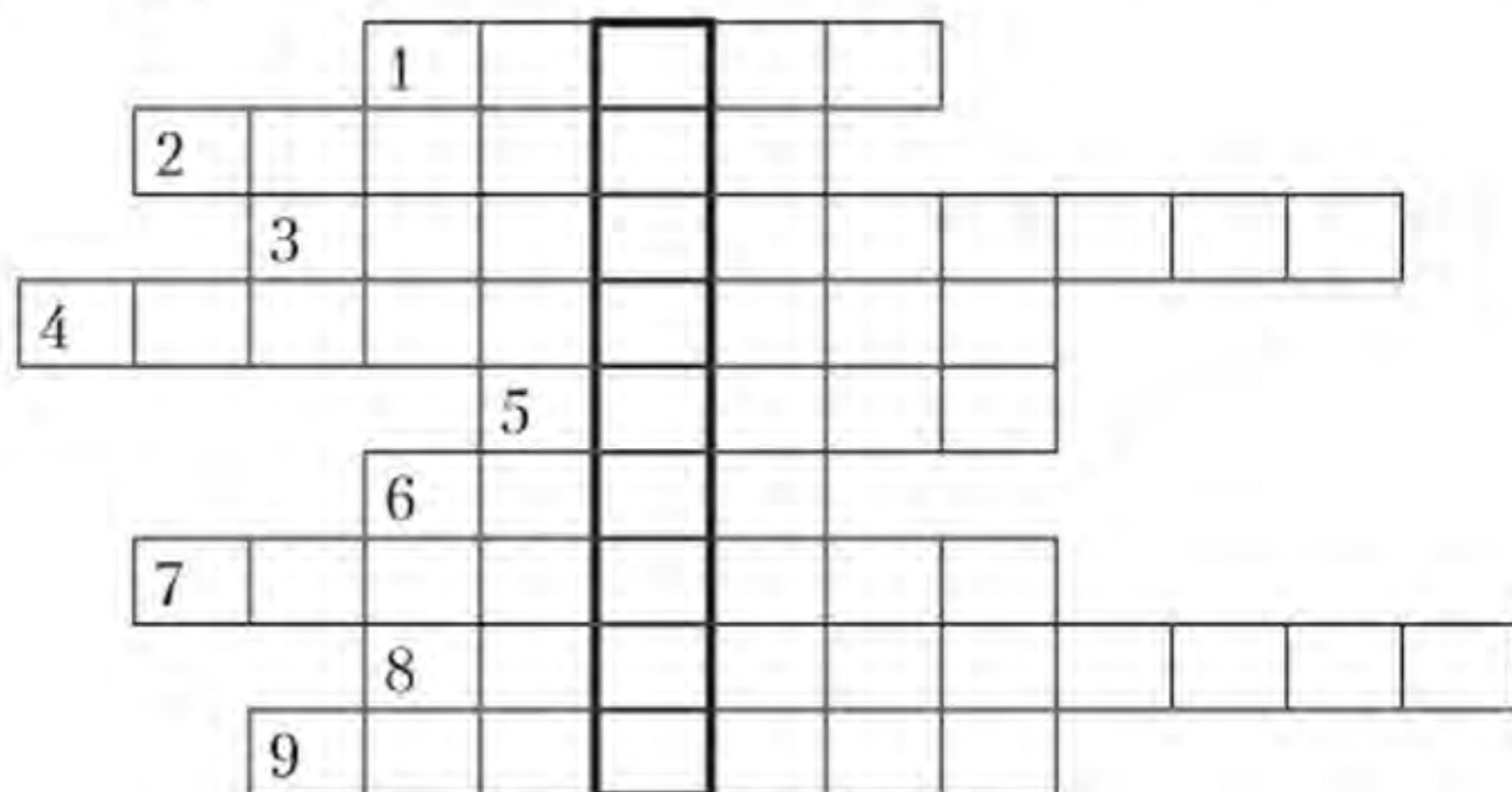
[paɪə'niə]

[dɪ'zaɪn]

['sɑ:mpəl]

[sə'dʒest]

3. Write the answers to the clues in your notebooks and find the vertical word.



1. Scientists usually publish their results and findings in it.
 2. An idea or set of ideas designed to explain something.
 3. The act of thinking of new ideas, developments, and improvements.
 4. A new machine, device, or product.
 5. A theoretical description of a phenomenon, system, or process.
 6. Scientists interpret it in order to reach conclusions.
 7. Critical examination.
 8. A scientific test.
 9. The study of the nature and behaviour of natural things.
4. Here is an extract from the article about J.J. Thomson's discovery of the electron. Before reading the text decide which words in the box below you will most probably come across.

conference, tube, experiment, theory, breakthrough, model, science, meeting, paper, laboratory, discovery, technology, formula, data, research, publish, equation

Now look through the text and notice the use of the words of **GSL**. Did you guess correctly?

Translate the text. Use a dictionary if necessary.

The **electron** — or at least our recognition of its existence as an elementary particle — passes the century mark this spring.

On April 30, 1897, Joseph Thomson reported the results of his recent experiments on cathode rays to a Friday evening meeting of the Royal Institution, suggesting these rays were composed of negatively charged pieces of atoms that he dubbed “corpuscles”.

cathode ['kæθəʊd]

royal ['rɔɪəl]

corpuscle ['kɔ:pʌsl]

Six months later he published an extensive account of these experiments in the Philosophical Magazine. One of the classic papers of modern physics, it opened the doors of human consciousness (сознание) to a radically new and often baffling (зара- dochный) world within atoms.

consciousness
['kɒnʃəsniːs]
baffling ['bæflɪŋ]

Together with the discovery of X-rays and radioactivity during the preceding two years, and the introduction of the quantum three years later, this breakthrough led to a revolutionary conception of matter that has since had major impacts on other sciences, on modern technology and art, and even on the way we talk and think.

quantum ['kwɒntəm]
major ['meɪdʒə]

(from *Beam Line*, 1997)

5. Fill in the gaps with appropriate prepositions. Use the word combinations in the sentences of your own. Write them down.

to obtain knowledge ... nature, scientific knowledge applied ... practical purposes, to work ... a particular area ... technology, to do research ... plasma, to refer ... the published results ... the research, to happen ... particular conditions, the validity ... experimental results, to work ... theories, to model phenomena ... a computer, a series ... equations, to come ... a conclusion, to submit an article ... a journal ... assessment ... publication, to give a presentation ... the work ... a conference, to deliver a paper ... a meeting, to present findings ... a conference ... these phenomena, to give a paper ... the recent developments ... this area

6. Give the English equivalents for the following Russian word combinations.

научные знания, применяемые в практических целях, конструировать новые машины, проводить исследования в определенной области, делать опыты, проводить эксперименты на образцах, получать информацию, проводить наблюдения, делать измерения, собирать и обрабатывать данные, прийти к выводу, проверить гипотезу, решать задачу, делать открытие, впервые выполнять работу в определенной области, подтверждаться наблюдениями, публиковать результаты в статьях, подать статью в журнал для опубликования, делать доклад на конгрессе

7. Answer the following questions making proper use of General Scientific Lexis.

1. How would you define *science*?
2. What do *technologists* concern themselves with?
3. What do we call a *prototype*?
4. Who are *innovators*?
5. What does *inventiveness* imply?
6. What do you engage in if you are *researchers*?
7. Why are *experiments* carried out?
8. What is the difference between a *field experiment* and a *thought experiment*?
9. What is a *laboratory bench*?
10. What is a *test tube*?
11. How is the *validity* of experimental results tested?
12. What do scientists do with *data*?
13. What does the word *empirical* mean?
14. How would you explain the word *breakthrough*?
15. What scientists are called *pioneers*?
16. Who are *theorists*?
17. Why are *models* designed?
18. What is a *theorem*?
19. What is a *formula*?
20. When do general statements become *laws*?
21. What does *deduction* refer to?
22. Where do scientists *publish* their *results* or *findings*?
23. Where do scientists give *presentations* of their work?
24. What is an *oral presentation*?

8. Study some typical collocations with “fulfilling” verbs. Use the collocations in sentences of your own.

	do	make	conduct	carry out	undertake	take
an analysis		v		v	v	
an attempt		v				
a contribution		v				
a discovery		v				
an experiment	v	v	v	v		
an investigation		v	v	v	v	
a measurement		v				
measures					v	v

	do	make	conduct	carry out	undertake	take
an observation		v				
a project				v	v	
a report		v				
research	v		v	v	v	
a study	v	v	v	v	v	

Language of Numbers and Shapes

Anyone who works in science and technology needs to be able to talk about numbers and shapes. Now check how well you can read, say and understand numbers, describe shape and give dimensions.

Dealing with Numbers

1. Notice how the following numbers are said in English.

Cardinal numbers

0	nought, oh ("zero" is not often used in reading decimal values)
375	three hundred and seventy five
2,064	two thousand and sixty four
3,180	three thousand one hundred and eighty
1,537,293	one million, five hundred and thirty seven thousand, two hundred and ninety three
2,000,000,000	two billion

Ordinal numbers and dates

5 March (5th March)	the fifth of March / March the fifth
1907	nineteen hundred and seven / nineteen oh seven

Fractions and decimals

$\frac{1}{2}$ a half	$\frac{1}{8}$ an eighth
$\frac{1}{3}$ a third	$\frac{3}{18}$ three-eighteenths / three over eighteen
$\frac{2}{3}$ two-thirds	$\frac{3}{165}$ three over one six five
$\frac{1}{4}$ a quarter	0.3 (nought) point three

$1\frac{3}{4}$ one and three-quarters 6.07 six point oh seven

$1\frac{1}{2}$ one and a half 10.75 ten point seven five

Percentages

35% thirty-five per cent

Temperature

24°C or °F twenty four degrees Centigrade / Celsius or Fahrenheit
[ˈfærənhaɪt]

-10° ten degrees below zero / minus ten degrees

Formulae reading

Basic formulae

1. Do you know how these formulae are spoken?

$a + b = c$ $a - b = d$ $a \times b = c$ $\frac{a}{b} = f$

Notice the signs which are used to indicate mathematical processes. Copy this into your notebooks.

<i>Signs</i>	<i>Spoken</i>	<i>Noun / Verb</i>
+	plus [plʌs]	addition / add
-	minus [ˈmaɪnəs]	subtraction / subtract
×	multiplied by / times	multiplication / multiply
:	divided by / over	division / divide

2. Memorise how the above formulae should be spoken.

a plus *b* equals *c*

a minus *b* equals *d*

a times *b* equals *c* / *a* multiplied by *b* equals *c*

a over *b* equals *f* / *a* divided by *b* equals *f*

3. More mathematical symbols to memorise.

These signs () are called “brackets”.

These signs [] are called “square brackets”.

ABC are capital letters.

abc are small letters.

A_x is read: A subscript x

$\bar{a}$ is read: a barred [ba:d]

4. Practise reading these formulae aloud.

$(a - b)(a + b) = y$	a minus b in brackets times a plus b in brackets equals y
$a(8 - b) = x$	a open brackets 8 minus b close brackets equals x
$\frac{12 + (a - b)}{7a} = b$	12 plus a minus b in brackets all over 7 a equals b
$x[(a - b)(a + b) - 7] = 0$	x open square brackets a minus b in brackets times a plus b in brackets minus 7 close square brackets equals nought [no:t]

5. Produce and recognise spoken forms of these simple formulae. Mind that the capital / small letter distinction is usually only made when both forms are used in the same equation.

1) $x = \frac{a + b}{c}$

6) $V = IR$

2) $x + y = \frac{A}{a - b}$

7) $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

3) $1 = a + (n - 1)d$

8) $v = u + at$

4) $Ft = mv - mu$

9) $\frac{dQ}{dz} = -q$

5) $\frac{1}{R} = \frac{M}{EI}$

10) $E = T + p - c + e$

6. Mind the full spoken version of these values. Practise reading them.

x^2	x squared
x^3	x cubed
x^n	x to the power (of) n / x to the n
x^{n-1}	x to the power (of) n minus 1 / x to the n minus one
x^{-n}	x to the power (of) minus n / x to the minus n
$\sqrt{x}$	square root of x
$\sqrt[3]{x}$	cube root of x
$\sqrt[n]{x}$	n th root of x

7. Write down the full spoken version of the following expressions. Read them out.

$$1) x^{-p} = \frac{1}{x^p}$$

$$6) y - y_1 = \left(\frac{y_2 - y_1}{x_2 - x_1} \right) (x - x_1) \quad -$$

$$2) x^{p/q} = \sqrt[q]{x^p}$$

$$7) \frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$$

$$3) b^2 = a^2(1 - e^2) -$$

$$8) x^2 - a^2 = (x + a)(x - a)$$

$$4) y = ae^{kx}$$

$$9) x^2 + y^2 + 2gx + 2fy + c = 0$$

$$5) x = \frac{nx_1 + mx_2}{m + n}$$

$$10) d = \sqrt{[(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2]}$$

More complex formulae

1. Study the following table and read the examples aloud.

Symbol	Meaning	Example	Spoken
$\equiv$	equivalent to	$x \equiv y$	x is equivalent to y
$\neq$	not equal to	$x \neq y$	x is not equal to y
$\approx, \simeq$	approximately equal to	$x \approx y$	x is approximately equal to y
$\rightarrow$	tends to	$x \rightarrow 0$	x tends to nought
$<$	less than	$x < 5$	x is less than five
$>$	greater than	$x > 5$	x is greater than five
$\ll$	much less than	$y \ll 5$	y is much less than five
$\gg$	much greater than	$y \gg 5$	y is much greater than five
$\leq$	less than or equal to	$x \leq 10$	x is less than or equal to 10
$\geq$	greater than or equal to	$y \geq 10$	y is greater than or equal to 10
∞	infinity	$x \rightarrow \infty$	x tends to infinity
$\propto$	proportional to	$x \propto y$	x is proportional to y
$\pm$	plus or minus	$x = \pm 2$	x equals plus or minus 2
/	per	km/hr	kilometres per hour

2. Here is the Greek alphabet. Make sure you know how this is read.

Capital / Small	Name	
A α	alpha	[ˈælfə]
B β	beta	[ˈbi:tə; US: ˈbertə]
Γ γ	gamma	[ˈgæmə]

<i>Capital / Small</i>	<i>Name</i>	
$\Delta \delta$	delta	[ˈdeltə]
$E \varepsilon$	epsilon	[epˈsaɪlən; US: ˈepsɪlən]
$Z \zeta$	zeta	[ˈzi:tə; US: ˈzertə]
$H \eta$	eta	[ˈi:tə; US: ˈertə]
$\Theta \theta$	theta	[ˈθi:tə; US: ˈθertə]
$I \iota$	iota	[aɪˈəʊtə]
$K \kappa$	kappa	[ˈkæpə]
$\Lambda \lambda$	lambda	[ˈlæmdə]
$M \mu$	mu	[mju:]
$N \nu$	nu	[nju: ; US: nu:]
$\Xi \xi$	xi	[ksaɪ]
$O o$	omicron	[əʊˈmaɪkrən; US: ˈɒmɪkrən]
$\Pi \pi$	pi	[paɪ]
$P \rho$	rho	[rəʊ]
$\Sigma \sigma$	sigma	[ˈsɪgmə]
$T \tau$	tau	[taʊ]
$Y \upsilon$	upsilon	[ju:pˈsaɪlən; US: ˈju:psɪlən]
$\Phi \phi$	phi	[faɪ]
$X \chi$	chi	[kaɪ]
$\Psi \psi$	psi	[psaɪ]
$\Omega \omega$	omega	[ˈəʊmɪgə; US: əʊˈmegə]

3. Practise reading out these expressions.

1) $f = \frac{1}{2\pi\sqrt{LC}}$	f equals one over two pi times the square root of LC
2) $E = \sigma I^4$	E equals sigma T to the power of four
3) $W_s = \frac{2\pi f}{P}$	Capital W subscript s equals two pi small f over capital P
4) $\gamma = \frac{W_0}{4\pi R} F$	Gamma equals W subscript oh over four pi R all times F
5) $\mu_0 = 4 \pi \times 10^{-7} Hm^{-1}$	Mu subscript oh equals four pi times ten to the power of minus seven capital H small m to the power of minus one
6) $C = \frac{L}{R^2 + \omega^2 L^2}$	C equals L over R squared plus omega squared L squared

7) $v_2 = \sqrt{\left(\frac{2e}{m}V_2\right)}$	<i>v</i> subscript two equals the square root of open brackets, two <i>e</i> over <i>m</i> times capital <i>V</i> subscript two, close brackets
8) $u = \frac{\frac{1}{2}\sigma_v^2}{K}$	<i>u</i> equals a half <i>sigma</i> subscript <i>upsilon</i> squared all over <i>K</i>
9) $\sigma = \frac{Myc}{I} - \frac{P}{A} +$	<i>sigma</i> equals capital <i>M</i> small <i>y</i> small <i>c</i> all over capital <i>I</i> , plus capital <i>P</i> over capital <i>A</i>
10) $\gamma = \frac{4Q}{3\pi R^2}(R^2 - r^2)$	<i>gamma</i> equals four <i>Q</i> over three <i>pi</i> <i>R</i> squared times, open brackets, <i>R</i> squared minus <i>gamma</i> squared, close brackets

4. Write down the following formulae in your notebooks. Check the results as a class.

- 1) *V* over *I* equals *R* (all capital letters)
- 2) *P* subscript one *V* subscript one equals *P* subscript two *V* subscript two (all capital letters)
- 3) one over *u* plus one over *v* equals one over *f* (all small letters)
- 4) capital *F* equals small *m* small *v* squared all over small *r*
- 5) one over *R* equals *M* over *EI* (all capital letters)
- 6) *sigma* over capital *Y* small *n* equals capital *M* over capital *A* small *h* capital *R* subscript small *f*
- 7) capital *A* equals two *pi* capital *R* subscript small *c*, open square brackets capital *R* subscript small *c* minus square root open brackets capital *R* subscript small *c* squared minus small *d* squared over four, close brackets, close square brackets
- 8) *tau* equals four capital *Q* over three *pi* capital *R* to the power of four, open brackets, capital *R* squared minus *gamma* squared, close brackets
- 9) *F* is proportional to *M* subscript one *M* subscript two all over *R* squared (all letters capital)
- 10) *T* squared over *R* cubed equals four *pi* squared over *GM* (all capital letters)

Describing angles and lines

1. Draw a vertical line, a horizontal line, two lines at an angle, a right angle, the line *AB* perpendicular to the line *DC*; the line *EF* at an angle of 45° to the line *FG*, two parallel lines, two intersecting lines.

Mind that statements about an angle can be made in three ways: $\hat{ABC}$ is a forty-five degree angle, $\hat{ABC}$ is an angle of forty-five degrees, *AB* is at an angle of forty-five degrees to *BC*.

The sign ' represents minutes, so that $120^{\circ}15'$ is read as a hundred and twenty degrees, fifteen minutes.

2. Complete the description of these angles. Use the words:

acute [ə'kju:t] (острый), obtuse [əb'tju:s] (тупой), reflex / external (внешний).

An angle $< 90^{\circ}$ is called "an _____ angle".

An angle $> 90^{\circ}$ is called "an _____ angle".

An angle $> 180^{\circ}$ is called "a _____ angle".

3. Present the following geometrical terms by drawing diagrams.

a) AB and CD are **parallel** lines.

b) FG is a **diagonal** [daɪ'ægən(ə)l] line.

c) IK and JL are **intersecting** lines.

Lines IK and JL **intersect** at X.

d) The line PN **bisects** the angle MNO.

PN is the **bisector** of the angle MNO.

Two dimensional shapes

1. Practise reading the adjectives relating to the shapes.

triangular [traɪ'æŋgjulə]

pentagonal [pen'tægən]

rectangular [rek'tæŋgjulə]

rhomboid ['rɒmbɔɪd]

circular ['sɜ:kjulə]

elliptical [ɪ'lɪptɪk(ə)l]

octagonal [ɒk'tægən]

2. Match the shapes with their descriptions.

1. square [skwɛə]

6. octagon ['ɒktəgən]

2. triangle ['traɪæŋɡl]

7. trapezium [trə'pi:ziəm]

3. rectangle ['rektæŋɡl]

8. trapezoid ['træpɪzɔɪd]

4. pentagon ['pentəgən]

9. rhomb [rɒm] / rhombus ['rɒmbəs]

5. circle ['sɜ:kl]

10. ellipse [ɪ'lɪps]

a) a four-sided figure having only two sides parallel;

b) a four-sided figure with equal sides and angles that are not right angles;

c) a plane figure with four equal sides and four right angles;

d) a plane figure with three straight sides;

e) a plane four-sided figure with four right angles;

f) a plane figure with five sides and five angles;

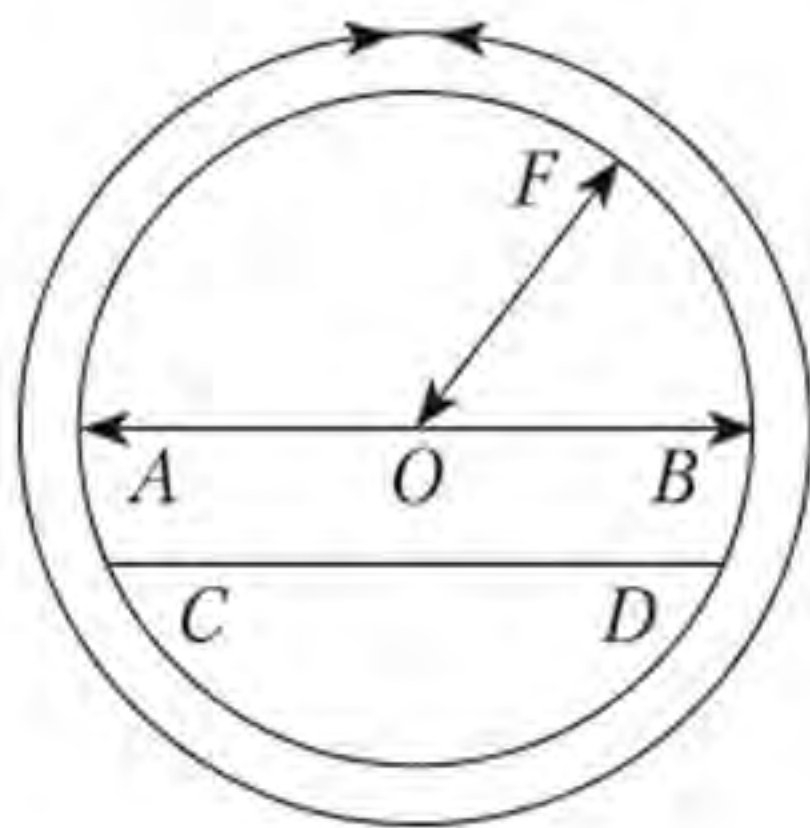
g) a space enclosed by a curved line, every point on which is the same distance from the centre;

h) a plane figure with eight sides and angles;

i) a four-sided figure having no sides parallel;

j) a regular oval ['əʊvl].

3. Show these parts of a circle.



1. circumference [sə'kʌmfərəns]
2. center
3. radius ['reɪdɪəs]
4. diameter [daɪ'æmɪtə]
5. chord

4. Draw different types of triangles.

ABC is an **equilateral** triangle.

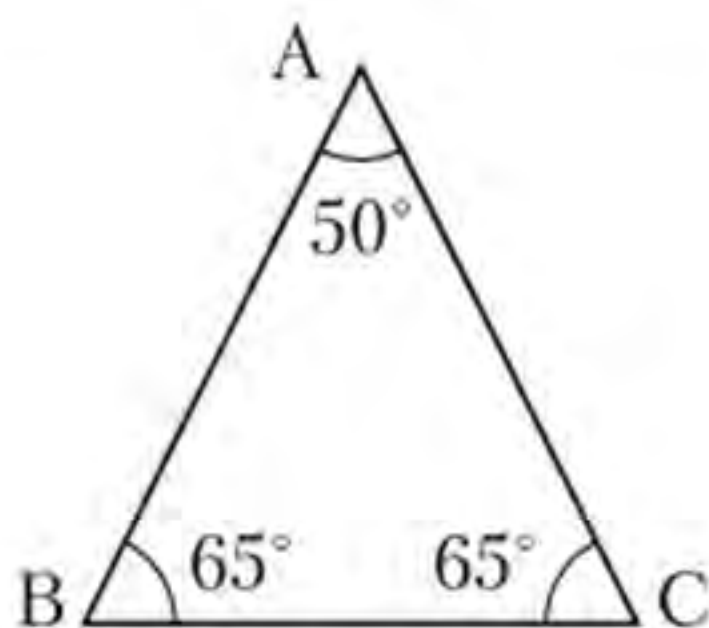
DEF is a **right-angled** triangle.

GHI is an **isosceles** [aɪ'sɒsəliːz] (равнобедренный) triangle.

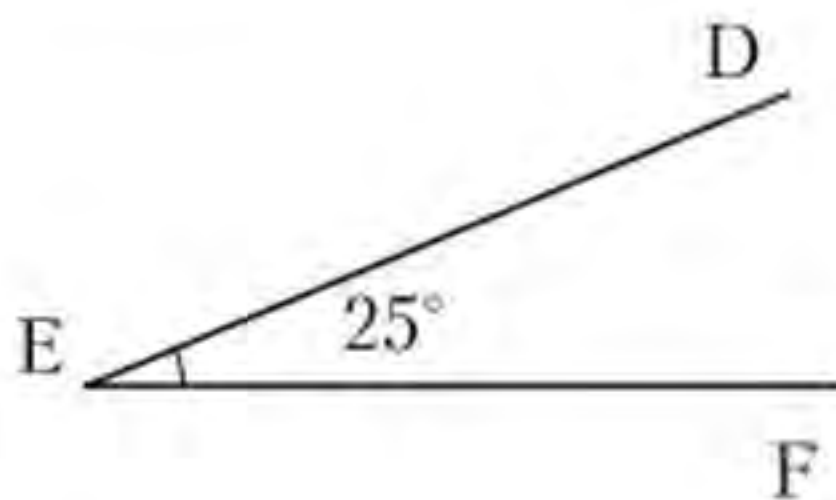
JKL is an **obtuse-angled** triangle.

MNO is an **acute-angled** triangle.

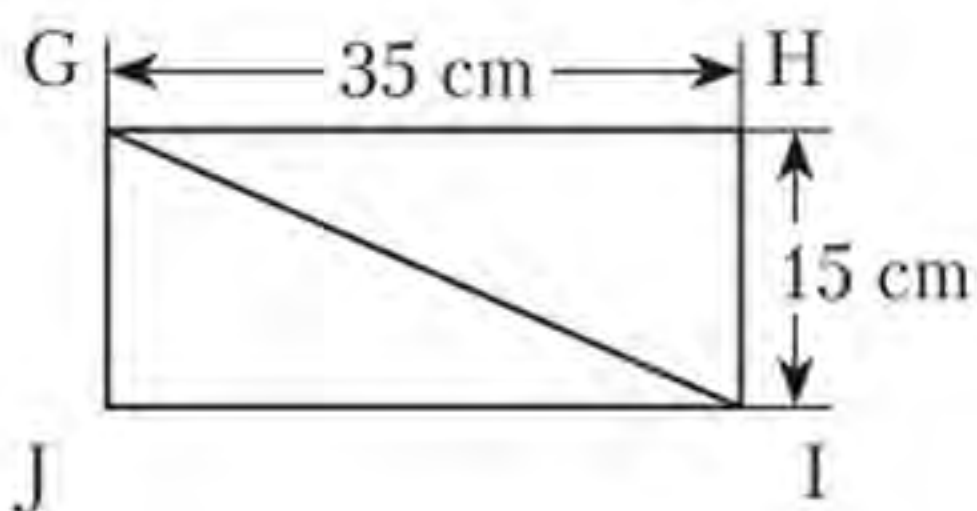
5. Memorise how these angles, lines and figures are described.



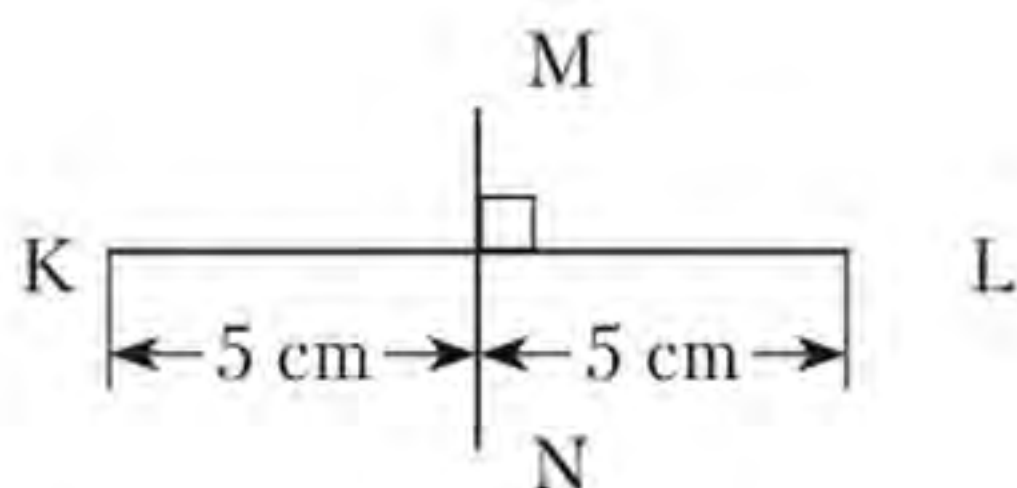
ABC is an isosceles triangle which has one angle of 50° and two angles of 65° .



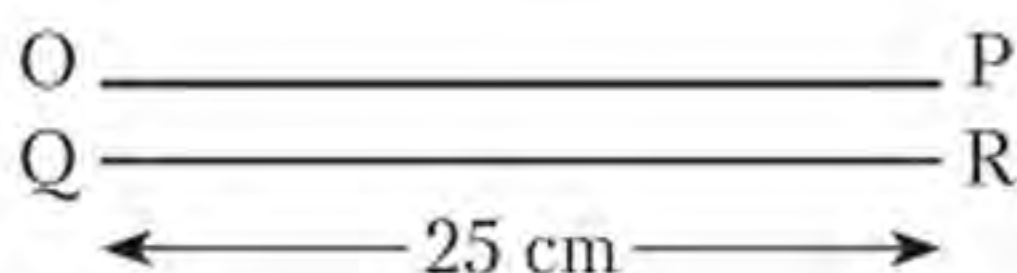
$\hat{DEF}$ is an acute angle of 25° .



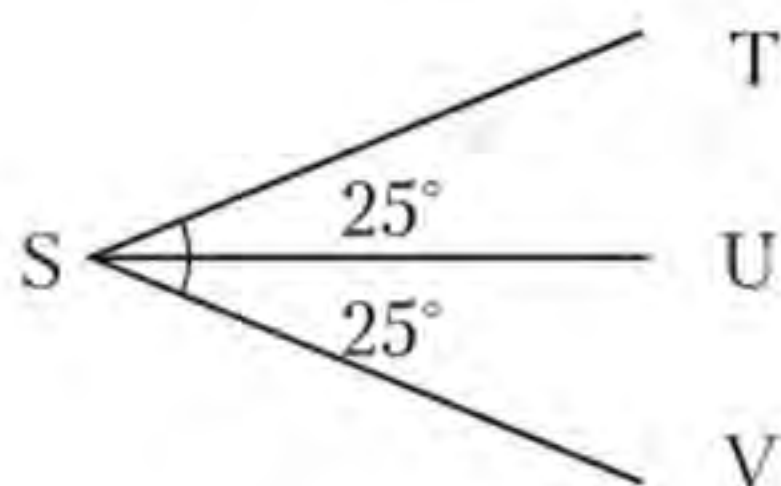
GHIJ is a rectangle of length 35 cm and width 15 cm, which has / with a diagonal GI.



The line MN bisects the line KL at right angles.



OP and QR are parallel lines of length 25 cm.



The acute angle TSV is bisected by the line SU.

6. Describe the figures above without looking at the notes on the right.

7. Follow these instructions and draw a figure. Compare your results with those of other students.

1) Draw a square of side 5 cm in the middle of the page. Label the square ABCD.

2) Draw two diagonal lines, AC and BD, in the square. Label the point of intersection X.

3) Draw a circle of radius 7 cm, with its centre at X.

4) Extend the diagonal AC to touch the circumference of the circle at A_1 and C_1 .

5) Extend the diagonal BD to touch the circumference of the circle at B_1 and D_1 .

6) Draw a line from A_1 to B_1 and from B_1 to C_1 .

7) Measure the lengths of A_1B_1 and B_1C_1 .

8) Measure the lengths of the diagonals AC and BD.

9) What sort of triangle is $A_1B_1C_1$?

10) Write down the values, from your drawing, of this formula:

$$A_1B_1^2 + B_1C_1^2 = A_1C_1^2.$$

8. Prepare a simple drawing. Work out a series of instructions for producing your drawing. Ask other students to follow your instructions and draw a similar drawing. Compare their drawings with the original. Analyse the drawings to find out whether any mistakes have been made.

Three-dimensional shapes

Match the following with their descriptions : a sphere ['sfɪə], a cube, a pyramid ['pɪrəˌmɪd], a cone, a cylinder ['sɪlɪndə].

- a solid figure that is entirely round;
- a solid body having six equal square sides;
- a solid body which narrows to a point from a round, flat base;
- a solid or hollow body with equal, circular ends and regular, curving sides;
- a structure with a triangular or square base and sloping sides meeting at a point.

Check yourself

1. Try this number quiz.

How do you say the following numbers in English?

597; $2\frac{1}{4}$; $3\frac{1}{2}$; 3,891; 9.18; 0.23; $3\frac{1}{3}$; $\frac{13}{391}$; 1,230,000; 37%;

10.03; 7 October; 10 August; 703 8266 (phone number); -6° centigrade; in 1908; in 2003; 10^{-4} ; 3^{10} .

How do you read this formula and what does it represent:
 $e = mc^2$?

How do you read this and what does it represent: $2\pi r$?

Read the following equations and expressions:

$$x^2 + 3x + 2 = 0$$

$$\frac{(1.56 \times 10^2) \times (2.0 \times 10^{-4})}{5.2 \times 10^5}$$

$$(x+2)(x+4) = 0$$

$$(5 \times 10^{10}) \times (3 \times 10^{-8}) \times (4 \times 10^6)$$

Write answers to these problems.

Add 10 and 6, multiply by 8, then subtract 40 and divide by 11. What have you got left?

Divide 33 by 11, multiply by 7, add 10, and subtract 16. What number is left?

2. Read these sentences aloud.

- Oxygen accounts for 46.6% of the earth's crust.
- Of the 2416 nominations in physics, three-quarters were for scientists from only four nations: Germany (25%), the US (21%), France (16%) and Britain (13%).
- Archive material related to the 1951 prizes was made available on 1 January 2002.
- The laboratory's main campus covers 1,700 acres in Chicago's western suburbs.

- The site has about 20,000 users and receives between 3,000 and 5,000 visitors a day.
- Two new components of our galaxy's atmosphere have come into view: hot (10^6 Kelvins) and warm (10^4 Kelvins) ionized hydrogen.
- The O- and B-type stars are 20 to 60 times heavier than the sun (a G-type star) and 10^3 to 10^5 times brighter.
- The proportion of parliamentary questions related to science and technology rose from less than 1% in 1988/89 to about 6% in 1998/99.
- The Brookhaven researchers reported their measurements in terms of an "anomalous magnetic moment" $a = (g - 2)/2$, obtaining a value of a of 11659202×10^{-10} .
- The relationship between the Celsius temperature T_C and the Fahrenheit temperature T_F is given exactly by the equation $T_C = \frac{5}{9}(T_F - 32 \text{ }^\circ\text{F})$.
- The Kelvin, or absolute temperature scale, is intimately related to the molecular motion and hence is used extensively in scientific work. Temperatures on the absolute, or Kelvin, scale are related to Celsius temperatures by $T = T_C + 273.15$.

3. Read the following solar and terrestrial data.

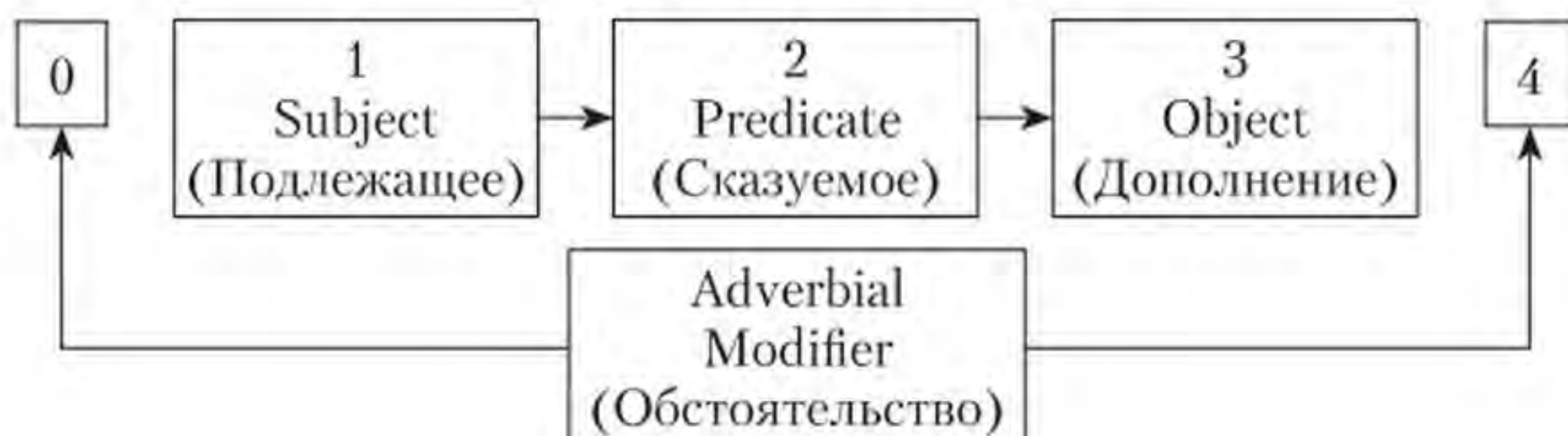
Speed of sound (dry air, 20°C)	344 ms^{-1}
Mass of Earth	$5.98 \times 10^{24} \text{ kilograms}$
Volume of Earth	$1.09 \times 10^{21} \text{ m}^3$
Mean radius of Earth	$6.38 \times 10^6 \text{ metres}$
Mean density	$5.52 \times 10^3 \text{ kg} \cdot \text{m}^{-3}$
Earth to Sun, mean distance	$1.50 \times 10^{11} \text{ metres}$
Mean orbital speed of Earth about the Sun	$2.98 \times 10^4 \text{ ms}^{-1}$
Sun, mean radius mass	$6.95 \times 10^8 \text{ metres}$ $1.99 \times 10^{30} \text{ kilograms}$
Moon, mean radius mass	$1.74 \times 10^6 \text{ metres}$ $7.35 \times 10^{22} \text{ kilograms}$
Earth to Moon, mean distance	$3.84 \times 10^8 \text{ metres}$

Grammar Focus

English is a word order language.
The meaning of what you say depends on the word order.

The Simple Sentence

The basic word order



Sentence Forms

A **sentence** can take one of the following **forms**:

- a **statement**: We argued against this method.
- a **question**: Are you good at languages?
- a **command**: Be careful!
- an **exclamation**: What a good idea!

In the passage below you will find different sentence forms. Can you name them?

A poet once said, "The whole universe is in a glass of wine." We will probably never know in what sense he meant that, for poets, do not write to be understood. But it is true that if we look at a glass of wine closely enough we see the entire universe. There are the things of physics: the twisting liquid which evaporates depending on the wind and weather, the reflections in the glass, and our imagination adds the atoms. The glass is a distillation of the earth's rocks, and in its composition we see the secrets of the universe's age, and the evolution of stars. What strange array of chemicals are in the wine? How did they come to be? There are the ferments, the enzymes, the substrates, and the products. There in wine is found the great generalization: all life is fermentation. Nobody can discover the chemistry of wine without discovering, as did Louis Pasteur, the cause of much disease. How vivid is the claret, pressing its existence into the consciousness that watches it! If our small minds, for some convenience, divide this glass of wine, this universe, into parts — physics, biology, geology, astronomy, psychology, and so on — re-

member that nature does not know it! So let us put it all back together, not forgetting ultimately what it is for. Let it give us one more final pleasure: drink it and forget it all!

(from *Six Easy Pieces* by R. Feynman)

Review of Tenses: Active Forms

1. Check whether you know the basic forms of the English verb.

	<i>Infinitive</i>	<i>Past Simple</i>	<i>Past Participle</i>	<i>Present Participle</i>
<i>Regular verbs</i>	to study to work to act	studied worked acted	studied worked acted	studying working acting
<i>Irregular verbs</i>	to do to make to come to have to write	did made came had wrote	done made come had written	doing making coming having writing

2. Give the forms of the following irregular verbs.

become, begin, bring, choose, deal, find, get, give, go, hold, keep, know, lose, meet, read, say, see, send, speak, spend, take, tell, think, understand, win

3. Study the tense table for the verb “write” in the active.

<i>Tenses</i>	<i>Present</i>	<i>Past</i>	<i>Future</i>
<i>Simple (Indefinite)</i>	write / writes	wrote	shall / will write
<i>Continuous (Progressive)</i>	am / is / are writing	was / were writing	shall / will be writing
<i>Perfect</i>	have / has written	had written	shall / will have written
<i>Perfect Continuous (Progressive)</i>	have / has been writing	had been writing	shall / will have been writing

4. Can you answer the following grammar questions?

What tense is used?

- if the ***time*** when the action happened is not important?
- if the ***time*** of the action is important?
- to express an activity in ***progress*** at a time in the past?
- to express an action that happened ***before*** a definite time in the past?
- to tell a story in a ***chronological*** order?

- f) to express a **completed** action at a definite time in the **past** or **past habits**?
 - g) to express a **past experience** the time of which is **not specified**?
 - h) to express the **present result** of a **past event**?
 - i) to express an activity in the **near future** or a **planned** future arrangement?
 - j) to describe an activity happening **now**, **around now**, and **temporary** activities?
 - k) to describe things that are **always true**, or **true for a long time**?
 - l) to express a **future** decision or intention made **at the moment of speaking**?
 - m) to express a **future fact**?
 - n) to express a **present habit**?
 - o) to express an action or state which began **in the past** and **still continues**?
 - p) to express an action which began **before the time of speaking in the past**, **continued up to that time**, or **stopped just before it**?
5. Look at the verbs in italics in the sentences below. Match the examples in A with the names of different tenses in B and comment on the use of the tenses.

A	B
1) He <i>made</i> a report on research in progress two weeks ago.	Present Simple
2) They <i>will discuss</i> the results of the experiment at the next seminar.	Past Simple
3) This book <i>provides</i> useful information.	
4) We <i>have</i> recently <i>resolved</i> some of our difficulties.	Future Simple
5) We <i>are taking</i> our examination in physics next month.	Present Continuous
6) We <i>have been solving</i> the problem for the last two hours.	
7) They <i>had been waiting</i> for a few hours before they could resume the experiment.	Past Continuous
8) The work <i>will give</i> valuable results.	
9) Study of these properties <i>is going</i> on a large scale.	Present Perfect
10) Prof. Brown <i>was working</i> at our laboratory last year.	Past Perfect
11) They <i>have worked</i> in this field for a long time.	Present Perfect
12) We <i>are working</i> on an interesting project now.	Continuous

A**B**

- 13) They **had found** a solution to the problem by the time we arrived. Past Perfect Continuous
- 14) He **has been** a lecturer for 10 years.

6. Read the text and retell it in the Present Simple using the questions below as an outline.

The principle of science, the definition, almost, is the following: The test of all knowledge is experiment. Experiment is the sole judge of scientific "truth". But what is the source of knowledge? Where do the laws that are to be tested come from? Experiment, itself, helps to produce these laws, in the sense that it gives us hints. But also needed is imagination to create from these hints the great generalizations — to guess at the wonderful, simple, but very strange patterns beneath them all, and then to experiment to check again whether we have made the right guess. This imagining process is so difficult that there is a division of labor in physics: there are theoretical physicists who imagine, deduce, and guess at new laws, but do not experiment; and then there are experimental physicists who experiment, imagine, deduce, and guess.

(*R. Feynman*)

1. What is the principle of science?
 2. What is the role of experiment and how does it help to produce the laws?
 3. What does one need to create the great generalizations?
 4. What division of labor is there in physics and why is it necessary?
 5. What do theoretical and experimental physicists have in common?
- 7. a) Decide which time expressions from the box below go together with the Past Simple which refers to a definite time in the past.**

for, since, ago, in 1980, just,
recently, at 10.00, yesterday,
last, never, before, already

b) Fill in the gaps with the correct verb.

- | | |
|---|-------------|
| He _____ his first lecture on physics in 1980. | make |
| I first _____ in an international conference two years ago. | give |
| He _____ this effect in 1991. | participate |
| We _____ this method last year. | observe |
| He _____ interested in physics last year. | suggest |

He _____ to study the nature of this phenomenon long ago. write
 They _____ a joint paper in 1998. begin
 He _____ a report at the conference yesterday. get

8. Change the following sentences into the Present Perfect using “just”, “already”, “recently”, “yet”, “never”, “ever”, “lately”.

1. They found similarities between the phenomena under study. (recently)
2. Physics made great advances in the investigation of this problem in the 20th century. (already)
3. He wrote a scientific paper a month ago. (just)
4. Did you send the editor a copy of your paper last week? (yet)
5. I attended seminars on superconductivity last year. (never)
6. Did you visit their research laboratory? (ever)

9. Make as many sentences with the Present Perfect as possible from the table.

Atomic physics	considerably improve	during / in the
High energy physics	become a large research center	past few years
This laboratory	develop into an independent	
The conditions for	area	during / in the
research work	make good progress	last decade
Scientists	work out a better approach	
	establish new facts	in recent years

10. Put the verbs in brackets in the correct tense, Present Perfect or Past Simple.

1. They (carry out) a series of experiments *this week*.
2. They (introduce) some new methods of investigation *lately*.
3. He (publish) a few papers on the problem *this year*.
4. We (clarify) this question *last week*.
5. Prof. Brown (give) some useful recommendations *a few days ago*.
6. There (be) heated discussion at the seminar *today*.
7. Dr. Clark (be) in charge of this project *for some time now*.
8. Our efforts (be) useless *so far*.
9. These studies (be) very intensive *until now*.

11. Correct the mistakes in the sentences.

1. How long do you know the chief of the laboratory?
2. This is the first time I made an oral presentation at a conference.
3. I study physics for six years.
4. When have you passed your exam?
5. I have applied for a new job yesterday.

12. Make up sentences with the Present Perfect Continuous.

Imagine that you are

- 1) making the experiment
- 2) designing the device
- 3) preparing for your examination in physics
- 4) examining the system
- 5) measuring the reaction rate
- 6) studying French

How long have you been doing this?

for a week / a month / a year / a few years?

since early morning / 9 o'clock / afternoon?

for half an hour / *for* about an hour / *for* the last two hours?

all the morning / all day long?

13. Change the sentences according to the model.

Example: He was testing the device when I came.

He had been testing the device for an hour when I came.

- 1) They were measuring pressure when I came.
- 2) We were following the course of the reaction when you phoned.
- 3) The machine was running when I left.
- 4) I was analyzing the samples when they came into the laboratory.

14. Match the translation with the original sentences. Comment on the use of the tenses.

Он пишет сейчас статью.

Он уже написал статью.

Он пишет статью в течение двух часов.

Он написал статью вчера.

На прошлой неделе они провели серию тестов.

Сейчас они проводят серию тестов в лаборатории.

На этой неделе они провели серию тестов в лаборатории.

Они проводят серию тестов в лаборатории с раннего утра.

He wrote the article yesterday.

He is writing an article now.

He has already written the article.

He has been writing the article for two hours.

They have carried out a series of tests in the laboratory this week.

They have been carrying out a series of tests in the laboratory since early morning.

They are carrying out a series of tests in the laboratory now.

They carried out a series of tests last week.

К концу недели они провели серию тестов в лаборатории.

They had carried out a series of tests in the laboratory by the end of the week.

Types of questions

General (Yes / No questions)	auxiliary (shall / will, have / has, had, am / is / are, do / does, did) + subject + predicate Does he hold the same opinion? Do they have any difficulties with the experiment? Did he make a thorough analysis of the data? Has he failed to solve the problem? be (full verb/ link verb) goes in front of the subject Is he at work? Is he good at maths? Was he a talented physicist?
Special (Information questions)	what who(m) when where why how which whose } + auxiliary + subject + predicate or be + subject ... What research are you engaged in at the moment? Why do you object to this proposal? When did he report these results? Subject questions who what } + verb (no inversion) Who discovered the atomic nucleus? What regulates the reaction rate? Who will join our research group?
Disjunctive (Tag questions) affirmative-negative negative-affirmative	statement + a short question This is the case, isn't it? There are a lot of challenging problems in physics, aren't there? They have seminars every week, don't they? It doesn't matter, does it? There is no way out, is there? The students don't know this rule well, do they?
Alternative (or questions)	general question + or ... Did he give a detailed description of the results or did he give a general outline of the research? Do they usually hold their meetings on Monday or on Tuesday?

1. Put general questions to the sentences below.

1. He always checks the equipment himself.
2. These phenomena occur very often.
3. They found no evidence in support of the view.
4. Their conclusions are quite reasonable.
5. The result obtained is reliable.
6. The magnetic field has become stronger.
7. They had solved the problem by the end of the month.
8. We haven't fulfilled our task yet.
9. Scientists are observing the effect in the laboratory now.

2. Write questions for words in italics.

1. *The outer electrons* leave the atom in some cases.
2. This material showed *unusual properties*.
3. The temperature is rising *gradually*.
4. *My colleague and I* approach the problem in the same way.
5. He has read a lot of books *on speciality*.
6. This method will give *good* results.
7. Each atom has *an electron cloud* in normal conditions.
8. He left the laboratory *late at night*.
9. Atoms contain *protons, neutrons, and electrons*.

3. Read about life events of Ernest Rutherford. Complete the questions and answers.

A famous British physicist Rutherford was born in New Zealand in 1871. He received his secondary training at Nelson college and graduated from the University of New Zealand in 1889. Four years later he got his M.A. degree (master's degree) with double first in mathematics and physics.

In 1895 Rutherford won a prize which took him to Cambridge University. At the Cavendish laboratory his ability was recognized at once. His earliest research there was a detector for electromagnetic waves.

In 1897 Rutherford worked upon the mobility of ions and related topics. He left Cambridge for Montreal. Later Rutherford continued his work at Cambridge on the radiation from radium and reported in 1899 that it is quite complex and consists of alpha rays and beta rays. Rutherford was one of the creators of the modern theory of radioactivity.

Rutherford won the 1908 Nobel prize in physics. His researches in radiation and atomic structure were basic to the later 20th century development in nuclear physics.

He died at Cambridge on October 19, 1937.

Mind the pronunciation of the following words:

Rutherford ['rʌðəfəd]

New Zealand [njuːˈzi:lənd]

Cambridge ['keɪmbɪdʒ]

Cavendish ['kævəndɪʃ]

Montreal [ˌmɒntriˈɔ:l]

Nobel ['nəʊbel], [nəuˈbel]

1. When _____? In 1871.

2. Where _____? In New Zealand.

3. Where _____? At Nelson College.

4. When _____? In 1889.

5. When _____? In 1893.

6. When _____? In 1895.

7. What _____ his earliest research? _____.

8. What _____ work upon in 1897? _____.

9. What _____ report in 1899? _____.

10. When _____? In 1908.

11. What _____ basic to the later 20th century development in nuclear physics? _____.

12. When _____? In 1937.

4. Complete the statements with the correct question tag.

1. The data are not in agreement with the previous observations.

2. These facts do not fit into the theory.

3. There is no evidence in favour of this hypothesis.

4. These results are reliable.

5. The conclusion proved false.

6. He has come to no conclusion yet.

7. They will carry out this experiment in the near future.

8. The equation is not true for elementary particles.

9. The observations are of practical value.

5. Ask for additional information.

1. Henry Becquerel discovered radioactivity (when? how? what?).

2. Oxygen is the most important constituent of air (who? when? what?).

3. Scientists worked out two different ideas about the nature of light (what? when? who?).

The following texts will help you to find answers to the questions.

Text 1

In view of the fact that we have to breathe oxygen in order to live, in addition to being more than half composed of it, we can safely call it the most important constituent of air. Its discovery as a separate gas is usually credited to the English chemist-clergyman, Joseph Priestley, who first prepared it in 1774 by heating mercuric oxide.

oxygen ['ɒksɪdʒən]

mercuric oxide

[mɜː'kjuəriːk 'ɒksaɪd]

gaseous ['ɡæsiəs]

Oxygen in its gaseous form is slightly heavier than air and will dissolve to a small extent in water. It is this dissolved oxygen that fish employ in respiration. Oxygen is used as the standard in our scale of atomic weights, being assigned a value of 16. It liquefies at a temperature of -297° F.

atomic [ə'tɒmɪk]

liquefy ['likwɪfaɪ]

Oxygen occurs widely in nature making up some 21 per cent of the atmosphere, about 47 per cent of the earth's crust, and some 65 per cent of the human body. Except for the oxygen in the atmosphere, essentially all of it is chemically combined with other substances.

Note: Fahrenheit is the name of a thermometer scale with freezing point at 32° and boiling point at 212° .

Text 2

The discovery of radioactivity was due more or less to pure accident. Once during the year 1896 Henry Becquerel, professor of physics at the Sorbonne obtained a preparation of uranium bisulphate for the purpose of studying the phosphorescence of this substance. But his interests were drawn in some other direction, and he threw the material into one of the drawers of his work-table.

Becquerel ['bek(ə)rəl]

Sorbonne [sɔː'bɒn]

uranium

[ju(ə)'reɪniəm]

bisulphate [baɪ'sʌlfet]

phosphorescence

[ˌfɒsfə'res(ə)ns]

Now it happened that in this drawer was a box containing some unexposed photographic plates, and the ampoule of uranium bisulphate fell right on top of that box, remaining there undisturbed for several weeks. Intending to take some photographs, Becquerel finally opened the drawer, pushed aside the ampoule with the forgotten preparation, and took out the box with the plates. But when he developed his photographs he found that the plates were badly spoiled, as if they had been previously exposed to light. This was very strange, since the plates had been carefully wrapped in thick black paper and never yet opened. The only object in the drawer that might have been responsible for the damage was the preparation of uranium bisulphate, which had for so long rested so close to the plates. He repeated the experiment with some new plates. But this time he deliberately placed an iron key from one of the drawers between the photographic plate and the hypothetical source of the mysterious radiation.

ampoule ['æmpu:l]

iron ['aɪən]

A few days later a diffuse silhouette of the key began to appear slowly against the darkening background of the negative. Yes, it definitely was a new kind of radiation coming from the atoms of uranium, a radiation that easily penetrated materials non-transparent to ordinary light, but was still unable to pass through the thickness of an iron key.

silhouette [ˌsɪlu'et]

Text 3

After scientists had begun to study the way light acts, they worked out two different ideas about the nature of light. At first these ideas did not agree. But as scientists have studied light still further, they have come to realize that both are right. One portrait of light is given by the theory, advanced by Newton, that light consists of a stream of

particles or corpuscles traveling in straight lines or rays. By means of this theory it is possible to explain many things including the laws of mirrors and lenses, and the formation of shadows. The other view of light, advanced by the Dutch scientist, Christian Huygens, at about the same time, is that light is a train of waves traveling through space. This theory also explains the laws of mirrors and lenses very well, and even the formation of shadows. Nevertheless, Newton's theory was favored for a long time and Huygens' was almost forgotten. Then, in 1801, an English scientist named Thomas Young did an experiment that could not be explained at all by Newton's corpuscular theory!

Huygens ['haɪɡənz]
corpuscular
[kɔ:'pʌskjʊlə]

6. Complete the “or” questions and ask other students to answer them.

1. Is oxygen lighter than air or ...?
2. Did Becquerel discover radioactivity by way of experiment or ...?
3. Did Newton advance the corpuscular theory of light or ...?
4. Do scientists support the wave theory of light or ...?

7. Write 5 tag questions to Text 1.

8. Write an outline of Text 2 in the form of questions.

9. Write all types of questions to Text 3.

Supplementary material for reading and discussion

You are going to read an extract from Richard Feynman's preface to Lectures on physics originally published in 1963. What do you know about this outstanding physicist? What are his most important contributions to science? As you read try to find answers to the following questions: What was Feynman's main concern in presenting the material and who did he address his lectures to? Were there any difficulties in giving the lectures? What idea have you got about Feynman the Educator?

The special problem we tried to get at with these lectures was to maintain the interest of the very enthusiastic and rather smart students coming out of the high schools and into Caltech. They have heard a lot about how interesting and exciting physics is — the theory of relativity, quantum mechanics, and other modern ideas. By the end of two years of our previous course, many would be very discouraged because there were really very few grand, new, modern ideas presented to them. They were made to study inclined planes, electrostatics, and so forth, and after two years it was quite stultifying. The problem was whether or not we could make a course which would save the more advanced and excited student by maintaining his enthusiasm.

The lectures here are not in any way meant to be a survey course, but are very serious. I thought to address them to the most intelligent in the class and to make sure, if possible, that even the most intelligent student was unable to completely encompass everything that was in the lectures — by putting in suggestions of applications of the ideas and concepts in various directions outside the main line of attack. For this reason, I tried very hard to make all the statements as accurate as possible, to point out in every case where the equations and ideas fitted into the body of physics, and how when they learned more — things would be modified. I also felt that for such students it is important to indicate what it is that they should — if they are sufficiently clever — be able to understand by deduction from what has been said before, and what is being put in as something new. When new ideas came in, I would try either to deduce them if they were deducible, or to explain that it was a new idea which hadn't any basis in terms of things they had already learned and which was not supposed to be provable — but was just added in.

At the start of these lectures, I assumed that the students knew something when they came out of high school — such things as geometrical optics, simple chemistry ideas, and so on. I also didn't see that there was any reason to make the lecture in a definite order, in the sense that I would not be allowed to mention something until I was ready to discuss it in detail. There was a great deal of mention of things to come, without complete discussions. These more complete discussions would come later when the preparation became more advanced. Examples are the discussions of inductance, and of energy levels, which are at first

brought in a very qualitative way and are later developed more completely.

At the same time that I was aiming at the more active student, I also wanted to take care of the fellow for whom the extra fireworks and side applications are merely disquieting and who cannot be expected to learn most of the material in the lecture at all. For such students, I wanted there to be at least a central core or backbone of material which he *could* get. Even if he didn't understand everything in a lecture, I hoped he wouldn't get nervous. I didn't expect him to understand everything, but only the central and most direct feature. It takes, of course, a certain intelligence on his part to see which are the central theorems and central ideas, and which are the more advanced side issues and applications which he may understand only in later years.

In giving these lectures there was one serious difficulty: in the way the course was given, there wasn't any feedback from the students to the lecturer to indicate how well the lectures were going over. This is indeed a very serious difficulty, and I don't know how good the lectures really are. The whole thing was essentially an experiment. And if I did it again I wouldn't do it the same way — I hope I *don't* have to do it again! I think, though, that things worked out — so far as the physics is concerned — quite satisfactorily in the first year.

In the second year I was not so satisfied. In the first part of the course, dealing with electricity and magnetism, I couldn't think of any really unique or different way of doing it — of any way that would be particularly more exciting than the usual way of presenting it. So I don't think I did very much in the lectures on electricity and magnetism. At the end of the second year I had originally intended to go on, after the electricity and magnetism, by giving some more lectures on the properties of materials, but mainly to take up things like fundamental modes, solutions of the diffusion equation, vibrating systems, orthogonal functions, developing the first stages of what are usually called "the mathematical methods of physics". In retrospect, I think that if I were doing it again I would go back to that original idea. But since it was not planned that I would be giving these lectures again, it was suggested that it might be a good idea to try to give an introduction to the quantum mechanics.

Discussion points

1. Do you agree with the statement that the teaching can be done only when there is a direct individual relationship between a student and a good teacher — a situation in which the student discusses the ideas, thinks about the things, and talks about the things?
2. Do you agree that it's impossible to learn very much by simply sitting in a lecture, or even by simply doing problems that are assigned?
3. What is your idea of a teacher-student relationship?
4. How should you study to achieve good results?

Physics problems for fun

Think about possible answers to the problems below.

1. Ground fields in lightning hit

If you are caught in a thunderstorm you should not stand under a tree, and you should keep your head lower than your surroundings. Why is the tree dangerous? As long as you stand away from the trunk, aren't you safe enough? Should you ever lie down? That would give your head the minimum possible elevation, but is there any additional danger encountered in lying down? Cows are often killed or hurt by lightning. Not only do they commonly stay outdoors and often seek shelter under trees, but the separation of their hind legs from their front legs increases danger. They are thus similar to a man lying down. Again, why is this dangerous?

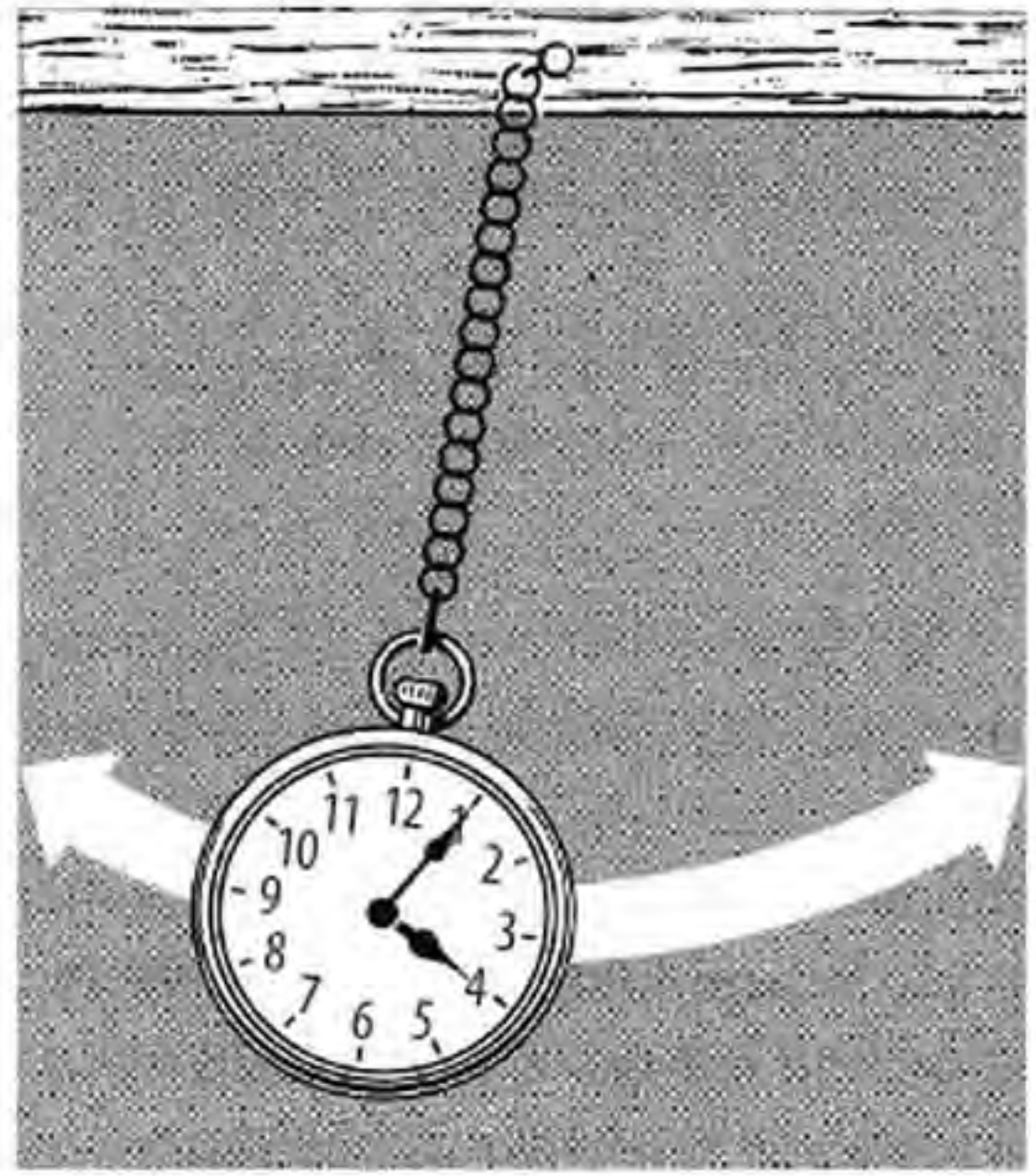
2. Boomerangs

Returning boomerangs are designed to be thrown great distances and to return to the thrower. Australian natives have thrown them as far as 100 yards and to heights of 150 feet with five complete circles. The nonreturning type, which is more practical for hunting, can be thrown as far as 180 yards.

The ordinary boomerang is shaped like a bent banana. Is it essential that the boomerang have this particular shape? Can one make a returning boomerang in the shape of an X or a Y? Most boomerangs are designed to be thrown with the right hand. What is the difference between left and right-handed boomerangs? Why does a boomerang (of any shape) return? Why does it loop around in its path? Finally, how does the path depend on the boomerang's orientation as it leaves the thrower's hand?

3. Swinging watches

Once hung on a chain, free to swing, should a pocket watch change its timekeeping rate? Many pocket watches do, even though they keep very good time if fastened down securely. If hung free on a chain by its stem, the watch will gradually begin to swing and may gain or lose up to 10 or 15 minutes a day. Why does it swing, and why does the timekeeping get messed up? Finally, why do some watches gain time while others lose time?



(from *The Flying Circus of Physics* by J. Walker)

Unit II

INSIGHT INTO BASIC PHYSICS

Grammar	Word Building. Review of Tenses: Passive Forms. Word Order: Grammatical and Stylistic Inversion
Skills	Reading and Speaking. Summarising. Solving Physics Problems

Warming up

Read the extract below and comment on the idea expressed in it.

Atoms in motion

If, in some cataclysm, all of scientific knowledge were to be destroyed, and only one sentence passed on to the next generations of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis (or the atomic fact, or whatever you wish to call it) that all things are made of atoms — little particles that move around in perpetual motion, attracting each other when they are a little distance apart, but repelling upon being squeezed into one another. In that one sentence, you will see, there is enormous amount of information about the world, if just a little imagination and thinking are applied.

(*R. Feynman*)

What statement, in your opinion, would contain the most information about our world in as few words as possible?

Can you illustrate the power of an atomic idea?

Reading I

Pre-text exercises

1. Where is the stress on these words? Put them in the correct column in your notebooks.

center, produce, atom, different, decrease, volume, distance, increase, attraction, repulsion, nuclear, measure, nucleus, relative

• • •	• • •	• •	• •

2. Practise reading the following words.

universe	[ˈju:nɪvɜ:s]	particular	[pəˈtɪkjulə]
various	[ˈveəriəs]	hadron	[ˈhædrɒn]
electromagnetic	[ɪˌlektɹəʊmæɡˈnetɪk]	gravitational	[ˌɡrævɪˈteɪʃn(ə)l]
intensity	[ɪnˈtensəti]	toward	[təˈwɔ:d]
correspondingly	[kɒrɪˈspɒndɪŋli]	tiny	[ˈtaɪni]
differentiate	[dɪfəˈrenʃiət]	isolated	[ˈaɪsəleɪtɪd]
electron	[ɪˈlektɹɒn]	fundamental	[ˌfʌndəˈmentl]
nucleus	[ˈnju:klɪəs]	neutron	[ˈnju:trɒn]

3. Practise reading the following word combinations.

different ways, various particles, particular variety, common term, decreasing strength, volume of space, force field, gravitational field, Earth's center, object's center, nuclear force, electromagnetic force, weak force, incredibly tiny distances, immediate neighborhood, isolated particles, relative strength, certain particles

4. In the box below are terms, words of general scientific lexis and general vocabulary. Which words are terms? Give their Russian equivalents.

four, way, particle, particular, interaction, force, use, term, decrease, strength, atom, nuclear, gravitation, volume, space, increase, attraction, repulsion, do, can, each, charge

5. Match the terms with their definitions.

1. atom	a) a physical agent which changes or tends to change the state of motion of a mobile body, or to change the shape of a fixed body
2. electron	b) the attractive force between any two pieces of matter; the magnitude of the force depends on the mass of the bodies and the distance between them
3. nucleus	c) a physical process in which two or more objects pull on each other; the action is mutual
4. force	d) a fundamental particle of mass 9.109×10^{-31} kg; it is negatively charged and carries a charge of 1.602×10^{-19} Coulomb
5. gravitation	e) a fundamental particle which has the same mass as an electron but a positive charge equal in magnitude to that of an electron

6. neutron	f) a fundamental particle having no charge and a mass of 1.675×10^{-27} kg
7. attraction	g) a part of an atom which gives the atom its mass; it is positively charged
8. positron	h) the smallest particle of an element which exhibits the properties of the element

Mind the pronunciation of the word **coulomb** ['ku:lɒm]

Pre-reading task

Here is an extract from the book "The Collapsing Universe" by Isaac Asimov. What do you know about this writer? Have you read any books written by him? Do you agree with the statement that in physics everything begins with forces?

Now read the text and answer the following questions:

1. What are the four forces or interactions that exist between the particles? Name them in order of decreasing strength.
2. What force is the strongest of the four?
3. What is the force field?
4. What does the Greek word "hadron" mean?
5. What are hadrons?
6. What are the nucleons?

The Four Forces

There are four different ways in which the various particles that make up the universe can interact with one another. Each of these is a particular variety of **interaction**, or to use a more old-fashioned but more common term, a **force**. Scientists have been unable to detect a fifth force, or yet, to find any reason why a fifth should be required.

The four forces are listed in order of decreasing strength in Tab. 1.

Table 1. Relative Strength of the Four Forces

<i>Force</i>	<i>Relative Strength</i>
nuclear	10^3
electromagnetic	1
weak	10^{-11}
gravitational	10^{-39}

Every particle in the universe is the source of one or more of these forces. Each particle serves as the center of a volume of space in which that force exists with an intensity that decreases

as the distance from the source increases. The volume of space in which that force can make itself felt is the force field.

Any particle that can serve as the source of a particular field will respond to such a field set up by another particle. The response is generally one of movement: the particles moving toward each other (**an attraction**) or away from each other (**a repulsion**) unless physically constrained from doing so.

Thus, any object capable of producing a gravitational field will, if placed in Earth's gravitational field, move toward Earth's center — that is, it will fall. The Earth will also move toward the object's center, but since it will likely be much larger than the falling object, it will rise correspondingly more slowly.

Of the four forces two — the **nuclear force** and the **weak force** — make themselves felt only at incredibly tiny distances of 10^{-13} centimeters or less. This is just about the width of the tiny nucleus that exists at the very center of the atom. It is only within the nucleus, in the immediate neighborhood of isolated particles, that these forces exist. For this reason the term **nuclear force** is sometimes given to both, and they are differentiated by their relative strength into the **strong nuclear force** and the **weak nuclear force**.

A given particle is not likely to produce and to respond to each of the forces. Only certain particles, for instance, produce and respond to the nuclear force. Those that do are called **hadrons**, from a Greek word meaning “strong”, since the nuclear force is the strongest of the four. The hadrons that are most common and most important to the structure of the universe are the two **nucleons** — the **protons** and the **neutrons**.

Word list

common (*adj*) — обычный, общий
constrain (*v*) — сдерживать;
вынуждать
correspondingly (*adv*) — соответственно
volume (*n*) — объем
increase (*v*) — увеличиваться
in the immediate neighborhood —
в непосредственной близости
incredibly (*adv*) — невероятно,
неправдоподобно
movement (*n*) — движение
particular (*adj*) — особый, специфический

old-fashioned (*adj*) — старомодный
reason (*n*) — причина, основание
require (*v*) — требовать
respond (*v*) — реагировать; отвечать
set up (*v*) — организовать; образовывать
source (*n*) — источник
space (*n*) — пространство
tiny (*adj*) — крошечный
universe (*n*) — вселенная
variety (*n*) — разновидность; разнообразие

Interpreting Data

Comment on the information in Table 1. Draw an appropriate conclusion from the data comparing the relative strength of the four forces. Structure your answer well. Notice the vocabulary which is used for referring to a table, diagram, chart, etc.

⇒ As can be seen from / in the	table chart diagram graph	}	...
⇒ According to As (is) shown in	Table 1 Figure 2 Chart 3	}	...
⇒ It can be seen from the	table diagram chart graph figures statistics	}	...
⇒ From	Table 1 table figures data results information	it can be	seen concluded shown estimated calculated inferred
the			that ...

Vocabulary Work

1. Mind the spelling differences in British English (BE) and American English (AE). Find examples of Americanisms in the text.

<i>BE</i>	<i>AE</i>
Spelling Variations	
aluminium [æljʊˈmɪniəm]	aluminum [əˈluːmɪnəm]
analyse	analyze
hypothesise	hypothesize
behaviour	behavior
neighbour	neighbor
colour	color
favour	favor

<i>BE</i>	<i>AE</i>
Spelling Variations	
catalogue	catalog
dialogue	dialog
centre	center
metre	meter
programme	program
traveller	traveler
practise (<i>v</i>)	practice (<i>v</i>)

2. a) Memorise the words of Greek and Latin origin.

sg (ед. ч.)

nucleus [ˈnju:klɪəs]
 phenomenon
 criterion [kraɪˈtɪəriən]
 datum
 formula
 analysis [əˈnæləsis]

pl (мн. ч.)

nuclei [ˈnju:klɪaɪ]
 phenomena
 criteria [kraɪˈtɪəriə]
 data [ˈdeɪtə] (данные)
 formulae [ˈfɔ:mju:li:], formulas
 analyses [əˈnæləsi:z]

b) Use a dictionary and give the plural form of the words below.

momentum (количество движения, импульс)
 medium (среда)
 radius
 axis [ˈæksɪs] (ось)
 basis
 hypothesis
 thesis

3. Check whether you know the following grammar words.

n=noun

существительное

v=verb

глагол

adj=adjective

прилагательное

adv=adverb

наречие

pron=pronoun

местоимение

prep=preposition

предлог

conj=conjunction

союз

num=numeral

числительное

4. Match a term and its abbreviation from B with a word from the text in A.

A	B
slowly	noun (<i>n</i>)
various	
interact	verb (<i>v</i>)
universe	
these	adverb (<i>adv</i>)
why	
from	adjective (<i>adj</i>)
incredibly	
common	pronoun (<i>pron</i>)
but	
particle	preposition (<i>prep</i>)
of	
find	conjunction (<i>conj</i>)
correspondingly	
within	numeral (<i>num</i>)
four	

5. Spelling and Pronunciation

Here are some words from the text in phonetics. Practise saying them. Then spell the words in your notebooks.

a	[ˈnju:klɪə]	e	[ˈtaɪnɪ]	k	[ˈaɪsələrtɪd]
b	[ˈju:nɪvɜ:s]	f	[dʒʌst]	l	[təˈwɔ:d]
c	[wɪdθ]	g	[ɪnˈkri:s]	m	[prəˈdju:s]
d	[ʃud]	j	[sɔ:s]	n	[ˈneɪbəhʊd]

6. Prepositions and adverbs

a) Memorise the use of prepositions and adverbs. Translate the phrases from the text into Russian.

to make up the universe, different ways in which ..., to interact with one another, a particular variety of interaction, to be listed in order of ..., the distance from the source, the volume of space, to serve as the source, to respond to smth, a field set up by another particle, to move toward Earth's center, to move away from each other, to be constrained from doing smth, to be capable of producing a gravitational field, of the four forces, at incredibly tiny distances of 10^{-13} centimeters, about the width of the tiny nucleus, at the very center of the atom, within the

nucleus, in the immediate neighborhood of isolated particles, for this reason, to be differentiated by their relative strength into ..., for instance, to be important to the structure of the universe

b) Fill in the gaps with appropriate prepositions and adverbs.

1. Various particles that make ... the universe interact ... one another ... four different ways.
2. Every particle ... the universe is the source ... one or more ... these forces.
3. The particles move ... each other or away ... each other unless they are constrained ... doing so.
4. Any object capable ... producing a gravitational field will move ... Earth's center if it is placed ... Earth's gravitational field.
5. The nuclear force and the weak force make themselves felt only ... incredibly tiny distances.
6. These forces exist only ... the nucleus, ... the immediate neighborhood ... isolated particles.
7. ... this reason the term nuclear force is given to both, and they are differentiated ... their relative strength ... the strong nuclear force and weak nuclear force.
8. Only certain particles, ... instance, produce and respond ... the nuclear force.

Reading II

1. Check the pronunciation of these words.

muon ['mju:ɒn]	baryon ['bæriɒn]	quark [kwɑ:k]
pion ['paɪɒn]	atomic [ə'tɒmɪk]	diversity [daɪ'vɜ:sɪti]
atom ['ætəm]	neutrino [nju'tri:nəu]	chaos ['keɪɒs]
meson ['mi:zɒn], ['mezon]	chamber ['tʃeɪmbə]	convergence [kən'vɜ:dʒəns]

2. Read the extracts carefully and give examples from the history of particle physics.

A

The electron was discovered in 1897 by the English physicist Joseph John Thomson (1856–1940), and it received its name because it was the smallest unit of electric charge then known (or for that matter, known today).

(from *The Collapsing Universe* by Isaac Asimov)

B

For the first few decades of the 20th century there didn't seem to be any trouble in saying what is meant by an elementary particle. J.J. Thomson could use the electric field in a cathode-ray tube to pull electrons out of atoms, so atoms were not elementary. Nothing could be pulled or knocked-out of electrons, so it seemed that electrons were elementary. When atomic nuclei were discovered in Ernest Rutherford's laboratory in 1911, it was assumed that they were not elementary, partly because it was known that some radioactive nuclei emit electrons and other particles, and also because nuclear charges and masses could be explained by assuming that nuclei are composed of two types of elementary particles: light, negatively charged electrons and heavy, positively charged protons.

(from *What Is an Elementary Particle* by Steven Weinberg)

C

In a celebrated experiment by James Chadwick (1891–1974) at the Cavendish Laboratory in 1932, the neutron was discovered. Chadwick at first believed that what he had discovered was Rutherford's neutron, that is, a proton-electron composite. More than a year after this experiment most physicists shared this view and hesitated to include the neutron among the true elementary particles: indeed, the atomic nucleus was usually considered to consist of protons, neutrons, and electrons. The claim that the neutron was a new elementary particle, a third fundamental constituent of ordinary matter, was first made by the Russian physicist Dmitri Ivanenko in 1932 and was soon adopted by Werner Heisenberg in his theory of atomic nucleus. The convergence of theory and experiment led in 1934 to the general acceptance of the neutron as an elementary particle; thus the electron was finally expelled from the nucleus after twenty years. In the mid-1930s it was realized that the proton and the neutron can be regarded as states of the same kind of particle for which the name "nucleon" was coined.

(from *Companion to the History of Modern Science*)

D

This was just the beginning of a great increase in the roster of so-called elementary particles. Muons were added to the list in 1937 (though their nature was not understood until later), and pions and strange particles in the 1940s. Neutrinos had been proposed by Wolfgang Pauli in 1930, and made part of beta-decay theory by Enrico Fermi [ˈfə:mɪ] in 1933,

but were not detected until the Reines-Cowan experiment of 1955. Then in the late 1950s the use of particle accelerators and bubble chambers revealed a great number of new particles, including mesons and baryons.

(from *What Is an Elementary Particle* by Steven Weinberg)

E

Shortly after the discovery of the pion, evidence was reported for the existence of new, unexpected particles. In 1947 George Rochester Butler from Manchester produced cloud chamber photographs of what were then called “V-particles”, recognized in the following years as heavy mesons. In 1951 some 15 elementary particles were identified, including new mesons known as the τ meson, the Λ meson and the θ meson. With the diversity of new particles the scene of particle physics seemed at the same time confusing and challenging. And yet the explosion of elementary particles had hardly begun.

(from *Companion to the History of Modern Science*)

F

In 1964 Murray Gell-Mann [$ˈmʌrɪ dʒel mæn$] and George Zweig of the California Institute of Technology independently proposed that all particles subject to the strong nuclear force are made up of more elementary constituents: the particles Gell-Mann named quarks. Particles subject to the strong force are called hadrons, and the so-called quark model was introduced in order to classify the proliferating new hadrons being generated in experiments with accelerators. According to this model each quark carries a fractional electric charge ($2/3$ and $1/3$ of the electron’s charge). Just as Mendeleev’s periodic system and Borh’s atomic model had brought order and unity to the chaos of the chemical elements so the quark model had reinstated order in the crowded world of elementary particles. The proton, the neutron, the mesons and all the other hadrons could now be considered manifestations of just a few fundamental quarks.

The original quark scheme includes three flavors, or kinds, of quarks, called up (**u**), down (**d**) and strange (**s**). The proton, for example, is made up of two **u** quarks and a **d** quark, whereas the neutron is made up of a **u** quark and two **d** quarks. Three more quark flavors have since been discovered; they are called charm (**c**), bottom or beauty (**b**) and top or truth (**t**).

(from *Companion to the History of Modern Science*)

Note: for that matter — если уж на то пошло
bubble chamber — пузырьковая камера
cloud chamber — камера Вильсона

3. What do the following dates refer to?

1897, 1911, 1930, 1932, 1934, 1937, 1947, 1951, 1955, 1964

4. Translate texts C and F into Russian with the help of a dictionary (in writing).

5. Make up a list of 10–12 questions to all the texts and discuss them in groups.

6. Today's elementary particles, the leptons (ν_e, e), (ν_μ, μ), (ν_τ, τ), and the quarks (u, d), (c, s), (t, b), form one of the pillars of our understanding of matter and energy. The quarks are colour triplets that experience the strong interactions. The leptons, which have no colour charge, do not.

Here is a chart (p. 61) with 12 elementary particles that are considered to be the “building blocks” of matter. Read it carefully and complete the analogous chart in your notebooks in English.

7. Write a brief description of the information contained in the chart. Begin your description like this:

There are two types of elementary particles: leptons and quarks. Both leptons and quarks can be sub-divided according to ... into

While classifying you may use the following words and phrases.

Nouns: criterion / criteria, basis / bases, features, characteristics, categories, classes, groups, types, kinds, sorts, species, families, members, sub-categories, sub-classes, sub-groups, sub-divisions, etc.

Verbs: classify, categorise, group, divide into, arrange (in), put into, fall into, place in, distinguish (between), differentiate (between / from), sub-classify, sub-categorise, sub-group, sub-divide, etc.

Useful phrases:

... consists of ... / comprises ... according to ...

... may be classified according to ... / on the basis of ... / depending (up)on ...

The classification is based (up)on ... / may be divided ... / may be sub-divided ... / may be further sub-divided ...

8. Use your notes to speak about the elementary particles.

Фундаментальные фермионы (<i>fermions</i>)	Лептоны		Кварки	
	-1	0	+2/3	-1/3
Электрич. заряд				
Частицы окружающего мира принадлежат этой группе.	Первое семейство	Электрон переносит электрический ток.	U-кварк (<i>up</i> — верхний) входит в состав протонов и нейтронов.	d-кварк (<i>down</i> — нижний) входит в состав протонов и нейтронов, открыт в 1964 г. $M = 6 \text{ МэВ}/c^2$
		Мюон — аналог электрона, время жизни — 2 микросекунды $M = 10^6 \text{ МэВ}/c^2$	с-кварк (<i>charm</i> — очарованный) открыт в 1974 г. $M = 1300 \text{ МэВ}/c^2$	s-кварк (<i>strange</i> — странный) открыт в 1964 г. $M = 100 \text{ МэВ}/c^2$
		Тау — аналог электрона, время жизни $3 \cdot 10^{-13} \text{ с}$, $M = 1777 \text{ МэВ}/c^2$	t-кварк (<i>top</i> — самый верхний или <i>truth</i> — истинный) открыт в 1995 г. $M = 175000 \text{ МэВ}/c^2$	b-кварк (<i>beauty</i> — прелестный) открыт в 1977 г. $M = 4300 \text{ МэВ}/c^2$
Эти частицы существовали в первый момент после Большого Взрыва (Big Bang). Теперь их можно обнаружить в космосе и на ускорителях частиц.	Второе семейство	Мюонное нейтрино — образуется при рождении и распаде мюонов $M < 0,2 \text{ МэВ}/c^2$		
		Тау-нейтрино — образуется при рождении и распаде тау-лептонов, открыто в 1975 г. $M < 20 \text{ МэВ}/c^2$		

Word building

1. Mind that the following suffixes are used to form different parts of speech.

nouns -er -ist -ence/-ance -(t)ion -ency -ment -ent -ty -ness -th -al
adjectives -able/-ible -al -ic -ous -ful -ive -ar -ary -like -less -ent
verbs -ize/ise -en -ate -(i)fy
adverbs -ly -ward

2. The words below are all from the text “The Four Forces”. Form the other parts of speech and mind the stress. If necessary use a dictionary.

<i>Noun</i>	<i>Adjective</i>
reason	
	magnetic
center	
response	
nucleus	
atom	
structure	
universe	
use	

<i>Verb</i>	<i>Noun</i>
	variety
interact	
detect	
exist	
serve	
	movement
produce	
isolate	

<i>Adjective</i>	<i>Noun</i>	<i>Verb</i>
		differentiate
strong		
weak		
	width	
	gravitation	
	intensity	
	attraction	
	repulsion	

3. Many adverbs end in *-ly*. Find examples of adverbs that end in *-ly* in the text. Do you know their meaning?
4. Note that these words are both nouns and verbs, with no change.

question	place	name	comment	force
change	reason	charge	report	model
attempt	act	note	research	contact
pioneer	approach			

These words have the same spelling but different pronunciation.

use (n) [ju:s]	vs	use (v) [ju:z]
object (n) [ˈɒdʒekt]	vs	object (v) [ɒbˈdʒekt]
impact (n) [ˈɪmpækt]	vs	impact (v) [ɪmˈpækt]
increase (n) [ˈɪnkri:s]	vs	increase (v) [ɪnˈkri:s]
decrease (n) [ˈdi:kri:s]	vs	decrease (v) [dɪˈkri:s]

5. Memorise the use of the following negative prefixes.

in-	incomplete, inadequate, ineffective, inconvenient, inaccurate
un-	unnecessary, unreasonable, unimportant, uncertain, unsuitable
im-	impractical, improbable, immoral, impure, implausible
ir-	irresponsible, irrespective, irrational
dis-	disadvantage, disapprove, disagree
non-	non-conductor, nonessential, nonexistent
mis-	misunderstanding, misprint, miscalculation
il-	illogical, illegal, illegible

6. Choose negative prefixes to form the opposites of the following words. Consult a dictionary if necessary.

active, known, common, cover, linear, possible, relevant, even,
appear, regular, perfect, literate, visible, valid, direct, exact, usual,
favourable, significant, suitable, sufficient

Active Vocabulary

common correspond general object	particular reason require respond	science use vary way
---	--	-------------------------------

1. common [ˈkɒmən] (*adj*) общий; обычный; свойственный

a ~ error / mechanism / result

общая ошибка и т.д.

to share a ~ property

обладать общим свойством

common to (all, both, every)

свойственный (всем, обоим, каждому)

to be in ~ use

обычно использоваться

to have much / little in ~

иметь много / мало общего

It's ~ practice to...

Принято...

It is ~ knowledge that...

Общезвестно, что...

~ sense	здравый смысл
in ~ with	как и
~ mistakes	общие ошибки
commonplace	обычный

2. correspond [kɒrɪ'spɒnd] (*v*) соответствовать (with, to); согласовываться; быть аналогичным (to); переписываться (with)

to ~ closely / exactly	точно соответствовать
------------------------	-----------------------

correspondence (*n*) соответствие; корреспонденция, переписка

to set up / establish a ~	устанавливать соответствие
to be in ~ with	находиться в соответствии с; переписываться с

a correspondence course	курс заочного обучения
-------------------------	------------------------

corresponding (*adj*) соответственный, соответствующий

a ~ member	член-корреспондент
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correspondingly (*adv*) соответственно

3. general ['dʒenərəl] (*adj*) общий, обычный; главный, основной

in a ~ sense	в общем смысле
in a ~ case / way	в общем случае
on a more ~ level	на более общем уровне
a very ~ category	очень общая категория
to be in ~ use	обычно использоваться
a ~ argument / class / law / method / problem / term	основной (-ая) довод / класс / закон / метод / проблема / термин
the ~ reader	массовый читатель
in ~	вообще
as a ~ rule	как правило, обыкновенно
~ observations concerning...	общие замечания, касающиеся...
in ~ terms	в общих чертах / выражениях

generality (*n*) обобщение

generally (*adv*) вообще, в основном, в общем

~ speaking	вообще говоря
It is ~ agreed / accepted / believed that...	Общепризнанно / Общепринято / Обычно считают, что...
~ recognized	общепризнанный

generalize (*v*) обобщать

to ~ facts / data / information

обобщать факты / данные и т.д.

4. object ['ɒdʒekt] (*n*) предмет, вещь, намерение, цель, объект

the prime ~

основная цель

a material / astronomical /
physical ~

материальный / астрономиче-
ский / физический объект

the ~ of an analysis / study

цель (предмет) анализа / исследо-
вания

to be the ~ of much / great / special
attention

являться предметом особого вни-
мания

~s of different nature

объекты разного рода

object [əb'dʒekt] (*v*) возражать, протестовать

to ~ strongly that

сильно возражать против того,
чтобы

to ~ to a proposal / statement

возражать против предложения /
утверждения

objection (*n*) возражение, протест

to raise an ~ against

выдвигать возражение против

Are there any ~s?

Есть возражения?

objective [əb'dʒektiv] (*n*) цель

the main ~

основная / главная цель

to meet the ~

достигнуть цели

5. particular [pə'tɪkjulə] (*n*) частность, деталь, подробность

particulars

подробный отчет; данные

in ~

в частности, в особенности

to go into ~s

переходить к деталям

particular (*adj*) частный, особый, специфический; требова-
тельный; обстоятельный

at this ~ point

как раз в этом месте

a ~ account

обстоятельный / детальный отчет

to focus on a ~ aspect

сосредоточиться на определенном
аспекте

Of ~ value is...

Особую ценность представляет...

Of ~ interest here is the fact that...

Особый интерес представляет то,
что...

~ attention has been given to...

Особое внимание уделено...

particularly (*adv*) особенно

6. reason ['ri:zn] (*n*) причина, довод, основание; разум, рассудок

a good / important / serious /
strong / logical ~

веский / важный / серьезный /
убедительный / логичный довод

a ~ against / for

довод против / в пользу

for several ~s

по нескольким причинам

for a number of ~s

по ряду причин

for this ~

по этой причине

with good ~

с полным правом / обоснованно /
справедливо

to explain/ give a ~ (for)

объяснять / мотивировать

by ~ of

вследствие

It is beyond ~ to do smth

Нет оснований делать что-л.

For ~s beyond the control of...

По причинам, не зависящим от...

It stands to ~...

Совершенно ясно / Очевидно,
что...; Разумеется, что...; Разумно
предположить, что...

We have every ~ to assume...

У нас есть все основания полагать,
что...

reason (*v*) — доказывать, убеждать, обсуждать

It is useless to ~ with him.

Его бесполезно убеждать.

reasonable ['ri:zənəbl] (*adj*) разумный, умеренный, приемлемый, достаточный

It is ~ to say / assume that...

Разумно сказать / предположить,
что...

unreasonable

неразумный, нереальный

reasonably (*adv*) довольно; разумно; справедливо; более или менее

~ good

довольно хороший

~ accurate results

более или менее точные результаты

One can ~ assume that...

Можно справедливо предполо-
жить, что...

reasoning (*n*) рассуждение, аргументация

7. require [rɪ'kwaɪə] (*v*) нуждаться, требовать

~ smth from / of smb

требовать что-л. от кого-л.

~ special attention / comment /
explanation / investigation /
knowledge

требовать особого внимания /
комментария / объяснения /
исследования / знания

A detailed analysis is required.

Требуется детальный анализ.

requirement [rɪ'kwaɪəmənt] (*n*) требование; условие; потребность

basic ~	основное требование
to meet / respond to / satisfy / suit the ~s	удовлетворять требованиям
to consider the ~s on	рассмотреть требования к
to be constrained by a ~	быть ограниченным требованием

8. respond [rɪ'spɒnd] (*v*) отвечать; реагировать

to ~ to a change / a requirement / smb's objection	отвечать на изменение / требование / чье-л. возражение
to ~ in different ways	реагировать различными способами

response [rɪ'spɒns] (*n*) ответ; реакция; отклик

the ~ of smth to smth	реакция чего-л. на что-л.
in ~ to	в ответ на
in ~ to critics / information	в ответ на критику / информацию
in ~ to your enquiry	в ответ на ваш запрос

responsibility [rɪ'spɒnsə'bɪlətɪ] (*n*) ответственность; обязанность

a personal ~	личная ответственность
a ~ for smth	ответственность за что-л.
a ~ to preserve nature	ответственность за сохранение природы
to take ~ for smth / smb	принимать на себя ответственность за что-л. / кого-л.
The ~ of doing smth rests with...	Ответственность за... лежит на...
The ~ is mine / on me.	Я несу ответственность.

responsible [rɪ'spɒnsəbl] (*adj*) ответственный; надежный

a ~ post	ответственный пост
to be ~ for	объяснять; являться причиной; обуславливать
an event ~ for a change / decay	событие, ответственное за изменение / распад

responsive [rɪ'spɒnsɪv] (*adj*) to реагирующий на

9. science [ˈsaɪəns] (n) наука

pure / applied ~	чистая / прикладная наука
computer ~	вычислительная техника
social ~s	общественные науки
an exact ~	точная наука
natural ~s	естественные науки
~ fiction	научная фантастика
adjacent ~s	смежные науки
related areas of ~	связанные области науки
a Ph.D. degree in the ~s	ученая степень кандидата наук
to advance / foster / promote ~	продвигать вперед науку
the ~s	естественные и точные науки

scientific [ˌsaɪənˈtɪfɪk] (adj) научный

~ achievement / analysis / data	научное достижение / научный анализ / научные данные
the growth of ~ knowledge	рост научных знаний
to appear in a ~ journal	появиться в научном журнале
~ set up / arrangement	научная аппаратура

scientist [ˈsaɪəntɪst] (n) ученый

a computer / nuclear ~	специалист в области ЭВМ / ученый-ядерщик
a team of ~s	коллектив ученых
~s in other fields	ученые в других областях

10. use [juːz] (v) употреблять; использовать; применять

to ~ effectively	эффективно использовать
to be widely ~d	широко использоваться
to be properly ~d	использоваться должным образом
to ~ to advantage	успешно использовать

use [juːs] (n) использование, применение

practical / specific / wide ~	практическое / специфическое / широкое использование
to be in common ~	часто использоваться, употребляться
to be no longer in ~	больше не использоваться
a wide field of ~s	широкая область использования
to be of (no) ~	быть (бес)полезным
to come into / get out of ~	войти в употребление / выйти из употребления
to make (good) ~ of	(успешно) использовать

user ['ju:zə] (*n*) пользователь; потребитель

a ~ of Email

пользователь электронной почты

a potential / computer ~

потенциальный потребитель /
компьютерный пользователь

useful ['ju:sful] (*adj*) эффективный; удобный; приемлемый; полезный, подходящий

~ approach / device / information

полезный метод / полезный прибор / полезная информация

useless ['ju:slis] (*adj*) непригодный; бесполезный; тщетный

It is ~ to do it.

Бесполезно делать это.

usefully ['ju:sfulɪ] (*adv*) успешно

to be ~ employed

успешно использоваться

usefulness (*n*) эффективность, достоинство

11. vary ['vɛəri] (*v*) меняться; изменяться; расходиться; отличаться; зависеть (от)

to ~ greatly / strongly / widely

сильно изменяться (отличаться)

to ~ between ... and / from ... to /
according to / in (size / shape) /
under different conditions

изменяться от ... до / от ... до /
в зависимости от / по (раз-
меру / форме) / при различных
условиях

to ~ with time

зависеть от времени

to ~ within / over wide limits

изменяться в широких пределах

to ~ in magnitude

изменяться по величине

to ~ inversely as

изменяться обратно
пропорционально

to ~ directly as

изменяться прямо
пропорционально

to ~ as

изменяться пропорционально

variable ['vɛəriəbl] (*n*) переменная величина

variable (*adj*) переменный; изменчивый

variance ['vɛəriəns] (*n*) разногласие; изменение; отклонение

variation [ˌvɛəriˈeɪʃn] (*n*) изменение; отклонение

~s of temperature

колебания температуры

~ from the norm

отклонение от нормы

to show little ~

обнаруживать незначительное
отклонение

varied ['vɛəriɪd] (*adj*) разный; разнообразный; различный

variety [vəˈraɪəti] (*n*) разнообразие; ряд; множество; разновидность, вид, сорт

a great / huge / wide ~

большое разнообразие

a ~ of cases / factors / phenomena

множество (ряд) случаев / факторов / явлений

in a ~ of cases

в ряде случаев

to propose a ~ of theories

предложить множество теорий

for a ~ of reasons

по ряду причин

various [ˈvɛərɪəs] (*adj*) различный, разный, разнообразный; многие

in ~ ways

различными способами

at ~ times

в разное время

from ~ angles

под разными углами

to perform ~ tasks

выполнять разные задачи

to try ~ approaches

пробовать различные подходы

varying (*adj*) изменяющийся

time ~

изменяющийся по времени

with ~ success

с переменным успехом

12. way [weɪ] (*n*) путь, дорога; направление; манера; средство, способ, образ, метод, прием

the only / best / wrong / right ~ of doing smth

единственный / лучший / неправильный / правильный метод (способ) сделать что-л.

on the ~ to

на пути к

in this ~

таким образом

in the same ~

таким же образом

in a different ~

по-другому

in one ~ or another

тем или иным способом, так или иначе

in a ~

в некотором отношении, в известном смысле

in any ~

в любом случае

~s and means

пути и способы

to find a ~ to do smth

найти способ / возможность сделать что-л.

by ~ of example

в качестве примера

by the ~

кстати, между прочим

to be under ~

находиться в процессе осуществления

to put it another ~

говоря другими словами

Vocabulary work

1. Match the words with similar meaning (synonyms) in two columns.

require	general
correspond	need
common	reaction
response	agree with
way	argument
vary	apply
reason	change
use	direction

2. Fill in the gaps with the suitable adjectives from the box. Sometimes several combinations are possible. Translate the sentences into Russian.

reasonable, useful, various, particular, general, common, scientific, responsible
--

- a) _____ definitions should be as exact as possible.
- b) This term is used in _____ senses.
- c) Of _____ importance is the dynamic behavior of the system.
- d) It is _____ to assume that these phenomena are interrelated.
- e) Specialists agree on the _____ principles cited above.
- f) It is important to emphasize what these sources have in _____.
- g) An asteroid was the event _____ for such changes.
- h) It is _____ to read books on speciality.

Words that you might want to know:

sense (<i>n</i>) смысл	emphasize (<i>v</i>) подчеркнуть
assume (<i>v</i>) предполагать	event (<i>n</i>) событие
agree (<i>v</i>) соглашаться	cite (<i>v</i>) цитировать

3. Consulting the Active Vocabulary

a) Translate the following word combinations from English into Russian and use some of them in the sentences of your own.

to be common to all, in common with, to correspond exactly, a correspondence between science and practice, a corresponding member, in general, generally speaking, to generalize facts, objects of different nature, to strongly object that, at this particular point, to focus on a particular aspect, with good reason, to give a reason for, by reason of, to require special attention, to consider the requirements on, to respond in different ways,

in response to your enquiry, a personal responsibility for, to be properly used, to be no longer in use, to be of no use, useful approach, to vary in opinions, to vary over time, to vary under different conditions, in a variety of cases, to perform various tasks, the only way of doing smth, in the same way, ways and means, to put it another way, natural sciences, a (PhD) degree in the sciences, the growth of scientific knowledge, a computer scientist, a team of scientists

b) Give the English equivalents for the following Russian words and word combinations.

иметь много общего, находиться в соответствии с, как правило, в общих чертах, предмет изучения, возражать против предложения, переходить к деталям, обстоятельный отчет, в частности, по ряду причин, отвечать требованиям, отвечать на изменение, в ответ на вашу критику, принимать ответственность за что-нибудь, являться причиной, широко использоваться, быть полезным, войти в употребление, изменяться в соответствии с, отклонения от нормы, множество факторов, различными способами, найти способ сделать что-то, в качестве примера, кстати, находиться в процессе осуществления, общественные науки, смежные науки, продвигать вперед науку, научные достижения, ученые в других областях

4. Find the logical ending on the right for each of the sentences on the left. There may be more than one variant.

It's common knowledge that...	to set up a correspondence between these factors.
It stands to reason that...	a detailed analysis is required.
As a general rule...	to try different approaches.
It is generally agreed that...	these objects are of different nature.
The object of an analysis is...	to use traditional methods of analysis.
Of particular interest is the fact that...	there is a variation from the norm.
One can reasonably assume that...	there is a correspondence between theory and practice.
It is useless...	these phenomena have little in common.
To put it another way...	to go into particulars.
It is useful...	to reason with him.

5. Put an appropriate preposition in the following gaps. Translate the sentences.

1. It is not possible to explain here all the variety _____ cases.
2. It is very easy to present data _____ this way.
3. This way _____ organizing the book has some drawbacks.
4. It is encouraging that the deployment of such a network is _____ way.
5. I have done my best to respond _____ all objections.
6. Such attempts have _____ general not succeeded.
7. Our analysis is incomplete _____ several reasons.
8. _____ particular, these criteria are typically engineering.

6. Translate the following sentences from English into Russian.

1. There is no good reason for preferring one method to another.
2. This article will give the general reader valuable insights into the way particle physicists are thinking today.
3. In a way, a theory allows you to see the forest instead of the trees.
4. Physicists have made good use of this theory to explain unusual properties of the substance.
5. Much progress toward an understanding of this mechanism has been achieved.
6. These phenomena have features in common with the convection.
7. These figures are in general agreement with the model.
8. Electron capture is more common with heavy isotopes.
9. The validity of new information is of particular importance.
10. Nucleic acids are responsible for protein synthesis.
11. Control materials should meet several requirements.
12. This correspondence with observation is excellent.
13. In general terms, there are three major aspects of the cosmological problem from Newton to Einstein.

7. Translate into English using the Active Vocabulary.

1. Эти явления имеют много общего. Общеизвестно, что существуют только два типа таких реакций (reactions). Эти волны обладают одним общим свойством (property). Будут обсуждаться проблемы, общие для всех областей знаний (areas of knowledge). Две кривые (curves) имеют общую точку. Как и другие естественные науки, физика быстро развивается (develop rapidly).

2. Данный проект (project) наиболее точно соответствует нашим требованиям. Это будет обсуждаться (discuss) в соот-

ветствующих разделах книги. Свойства этих веществ (substances) должны изменяться соответствующим образом. Эта диаграмма (diagram) устанавливает соответствие между двумя параметрами (parameters).

3. Это очень общая категория. Он попытался объяснить проблему в общих чертах. Вообще говоря, этот процесс протекает гораздо медленнее (be much slower), чем мы ожидали (expect). Как правило, в этом случае температура поднимается. Эти книги должны быть доступны (be accessible to) массовому читателю. Общеизвестно, что этот метод наилучший.

4. Основная цель заключалась в том, чтобы определить (determine) давление газа. Механизм (mechanism) реакции является предметом нашего исследования. Эта область физики давно является предметом особого внимания. Возражение против этих теорий вполне (quite) обосновано (justify). Любой объект, помещенный в гравитационное поле Земли, упадет. Они сильно возражали против того, что эти явления взаимосвязаны. Я не возражаю против этого метода исследования.

5. Они описали (describe) особый тип взаимодействия. Мы исследовали это явление во всех подробностях. Обратите особое внимание (pay attention to) на эти аспекты проблемы. В этой статье я попытаюсь (attempt) проанализировать новые свойства вещества, в частности, его реакцию (response to) на вибрацию (vibration). Особое внимание уделено использованию нового метода. Давайте перейдем к деталям. Особую ценность представляет определение (determination) всех параметров.

6. По этой причине интенсивность уменьшается. Наш анализ неполный (incomplete) по нескольким причинам. Другим доводом в пользу этого метода является то, что он гораздо более безопасный (safe). Я объяснил выбор темы (subject matter) своего исследования (research). Совершенно очевидно, что взаимодействие частиц будет очень слабым в этом случае. Эксперимент не удался (fail) по причинам, не зависящим от ученых. У нас есть все основания предполагать, что результаты будут интересными. Разумно предположить, что расстояние между объектами будет невероятно (incredibly) маленьким. Этот метод можно справедливо критиковать за (criticize for) серьезные недостатки (limitations). Нет оснований надеяться на (hope for) хорошие результаты.

7. От этих приборов (devices) требуется большая точность (great accuracy). Основное требование к любому прибору заключается в том, чтобы он был точным (precise). Требования к качеству (quality) частей достаточно строгие (rigid). Это оборудование (equipment) должно отвечать требованиям современной (modern) лаборатории. Мы измерили (measure) время, необходимое для этой реакции. Новые машины (machines) строятся в соответствии с требованиями заказчика (customer).

8. Мы изучаем реакцию живых организмов (living organisms) на воздействие физической силы. В ответ на напряжения (stresses) тело мобилизует (mobilize) систему защитной реакции (defensive reaction). Эта эмульсия (emulsion) реагирует в основном (chiefly) на зеленый свет. Адроны — единственные частицы, реагирующие на сильное взаимодействие. Ответственность за то, что может произойти, будете нести вы. Ответственность за проведение этого эксперимента лежит на вашей лаборатории. Электромагнитное взаимодействие является причиной притяжения частиц.

9. Претендент (candidate) должен представить (produce) диссертацию (dissertation for) на получение ученой степени кандидата наук. Международные встречи (meetings) ученых способствуют развитию (promote) личных (personal) контактов. Это научное открытие имеет большое практическое значение (be of great practical significance). Я написал научный доклад (paper), основанный на последних (recent) результатах (findings). Вычислительная техника быстро развивается. Это величайшее открытие современной науки.

10. Этот термин используется в различных смыслах. Наш метод эффективно использовался в последних экспериментах. Они успешно использовали знание новых свойств данного вещества (substance). Такие материалы больше не используются в экспериментальных исследованиях. Бесполезно проводить опытное исследование (pilot study) сейчас. Это наиболее эффективный подход к (approach to) решению задачи (solution to / of the problem). Их методика эксперимента (experimental procedure) широко используется.

11. Кристаллы (crystals) изменяются в цвете в зависимости от количества (amount) железа. Ток (current) изменяется со временем. Эти силы изменяются по величине. Коэффициент (coefficient) изменяется линейно (linearly) с температурой. Длина цилиндра (cylinder) может изменяться в широких пределах. При постоянной температуре (at constant

temperature) объем газа изменяется обратно пропорционально давлению. Объем газа изменяется прямо пропорционально абсолютной (absolute) температуре. Колебания температуры были слишком незначительными.

12. Это единственный способ контролировать процесс. Лучший способ представить (present) материал — разделить (divide) его на несколько частей. На пути к этому открытию было много трудностей. Есть несколько способов решения этой задачи. В качестве примера рассмотрим (consider) уравнение (equation) 2. Частицы передвигаются (travel) во многом таким же образом. Он по-другому описывает это явление. Образцы (samples) анализировались различными способами. Программа развития осуществляется в течение двух лет. Говоря другими словами, мы не знаем, как ответить на этот вопрос. Между прочим, никакая теория не дает (offer) удовлетворительного (satisfactory) объяснения этому факту.

Development

1. Read a passage from “Six Easy Pieces” by R. Feynman and entitle it. Compare the information it contains with the information from the text about the fundamental forces in nature. What physical concepts are treated in these texts?

Before 1920, our world picture was something like this: The “stage” on which the universe goes is the three-dimensional space of geometry, as described by Euclid, and things change in a medium called time. The elements on the stage are particles, for example the atoms, which have some properties. First, the property of inertia: if a particle is moving it keeps on going in the same direction unless forces act upon it. The second element, then, is forces, which were then thought to be of two varieties: First, an enormously complicated, detailed kind of interaction force which held the various atoms in different combinations in a complicated way, which determined whether salt would dissolve faster or slower when we raise the temperature. The other force that was known was a long-range interaction — a smooth and quiet attraction — which varied inversely as the square of the distance, and was called gravitation. This law was known and was very simple. Why things remain in motion when they are moving, or why there is a law of gravitation was, of course, not known.

A description of nature is what we are concerned with here. From this point of view, then, a gas, and indeed all matter, is a myriad of moving particles. Thus many of the things we saw while standing at the seashore can immediately be connected. First the pressure: this comes from the collisions of the atoms with the walls or whatever; the drift of the atoms, if they are all moving in one direction on the average, is wind; the random internal motions are the heat. There are waves of excess density, where too many particles have collected, and so as they rush off they push up piles of particles farther out, and so on. This wave of excess density is sound. It is a tremendous achievement to be able to understand so much.

What kinds of particles are there? There were considered to be 92 at that time: 92 different kinds of atoms were ultimately discovered. They had different names associated with their chemical properties.

The next part of the problem was, what are the short-range forces? Why does carbon attract one oxygen or perhaps two oxygens, but not three oxygens? What is the machinery of interaction between atoms? Is it gravitation? The answer is no. Gravity is entirely too weak. But imagine a force analogous to gravity, varying inversely with the square of the distance, but enormously more powerful and having one difference. In gravity everything attracts everything else, but now imagine that there are two kinds of "things", and that this new force (which is the electrical force, of course) has the property that likes repel but unlikes attract. The "thing" that carries this strong interaction is called charge.

Then what do we have? Suppose that we have two unlikes that attract each other, a plus and a minus, and that they stick very close together. Suppose we have another charge some distance away. Would it feel any attraction? It would feel practically none, because if the first two are equal in size, the attraction for the one and the repulsion for the other balance out. Therefore there is very little force at any appreciable distance. On the other hand, if we get very close with the extra charge, attraction arises, because the repulsion of likes and attraction of unlikes will tend to bring unlikes closer together and push likes farther apart. Then the repulsion will be less than the attraction. This is the reason why the atoms, which are constituted out of plus and minus electric charges, feel very little force when they are separated by appreciable distance (aside from gravity). When they come close together, they can "see inside" each other and rear-

range their charges, with the result that they have a very strong interaction. The ultimate basis of an interaction between the atoms is electrical. Since this force is so enormous, all the pluses and all minuses will normally come together in as intimate a combination as they can. All things, even ourselves, are made of fine-grained, enormously strongly interacting plus and minus parts, all neatly balanced out. Once in a while, by accident, we may rub off a few minuses or a few plusses (usually it is easier to rub off minuses), and in those circumstances we find the force of electricity unbalanced, and we can then see the effects of these electrical attractions.

To give an idea of how much stronger electricity is than gravitation, consider two grains of sand, a millimeter across, thirty meters apart. If the force between them were not balanced, if everything attracted everything else instead of likes repelling, so that there were no cancellation, how much force would there be? There would be a force of three million tons between the two! You see, there is very, very little excess or deficit of the number of negative or positive charges necessary to produce appreciable electrical effects. This is, of course, the reason why you cannot see the difference between an electrically charged or uncharged thing — so few particles are involved that they hardly make a difference in the weight or size of an object.

With this picture the atoms were easier to understand. They were thought to have a “nucleus” at the center, which is positively electrically charged and very massive, and the nucleus is surrounded by a certain number of “electrons” which are very light and negatively charged. Now we go a little ahead in our story to remark that in the nucleus itself there were found two kinds of particles, protons and neutrons, almost of the same weight and very heavy. The protons are electrically charged and the neutrons are neutral. If we have an atom with six protons inside its nucleus, and this is surrounded by six electrons (the negative particles in the ordinary world of matter are all electrons, and these are very light compared with the protons and neutrons which make nuclei), this would be atom number six in the chemical table, and it is called carbon. Atom number eight is called oxygen, etc., because the chemical properties depend upon the electrons on the outside, and in fact only upon how many electrons there are. So the chemical properties of a substance depend only on a number, the number of electrons. (The whole list of elements of the chemists really could have been called 1, 2, 3, 4, 5, etc. Instead of saying “carbon”, we could say “element six”,

meaning six electrons, but of course, when the elements were first discovered, it was not known that they could be numbered that way, and secondly, it would make everything look rather complicated. It is better to have names and symbols for these things, rather than to call everything by number.)

2. Read the text again. Write an outline of the text in the form of questions and let other students answer them.
3. Retell the text using the outline.
4. Translate the text at sight. Try to guess the meaning of the unknown words from the context.

Charge and the Structure of Matter

While it requires sophisticated mathematics to describe atoms and molecules fully, a simple atomic model gives some insight into charges, their properties, and the role they play in nature. There are slightly more than 100 naturally occurring or artificially produced atomic species or **elements**. The typical atomic radius is 10^{-10} m. The model pictures atoms as rather like a solar system, with negatively charged **electrons** orbiting a dense, positively charged **nucleus**. The attractive electric force between the negative electrons and positive nucleus holds the atom together, just as the gravitational attraction holds the solar system together. When an atom has its full complement of electrons, it is electrically neutral; that is, its total charge is zero. If one or more electrons are added or taken away, the atom is said to be **ionized**.

The constituents of the massive nucleus were not completely identified until the 1930s. These constituents, collectively called **nucleons**, are **neutrons** that are uncharged and **protons** that have a positive charge. The proton charge is denoted by ***e*** and is exactly equal in magnitude to the electron charge, ***-e***. A neutron or proton is approximately 1800 times as massive as an electron. A typical nuclear radius is 10^{-14} m, some 10,000 times smaller than that of the atom. One may well ask how a nucleus can have many positively charged protons so close together if they repel each other. The explanation depends on the existence of still another fundamental force of nature that does not depend upon charge. If two protons approach each other, they electrically repel each other more and more strongly until they are close enough for the **strong nuclear force** to take effect. This force overwhelms the electric repulsion and holds the protons together.

Atoms combine in various ways, all of which depend on the electric forces produced by charges, to form molecules and macroscopic objects that, in their normal state, are electrically neutral. Thus common objects are not ordinarily charged, but their existence and solidity depend on charges being present in their microscopic structure.

(from *General Physics*)

5. Define or explain the italicised words from the text.

6. Read the text and render it in English making good use of the terms and Active Vocabulary of the Unit.

АТОМЫ И МОЛЕКУЛЫ

Все вещества состоят из (consist of) крошечных частиц — атомов. Атомы соединяются (combine) в молекулы, крупнейшие из которых имеют сложное строение, состоящее из тысяч атомов.

О том, что все сущее состоит из частиц, знали еще древние греки (ancient Greeks). Около 420 г. до н.э. философ Демокрит (Democritus) поддержал гипотезу, что материя состоит из крошечных, неделимых (indivisible) частиц. По-гречески *atomos* означает «неделимый», поэтому эти частицы называли атомами.

Другие философы придерживались иной точки зрения, и в IV веке до н.э. Аристотель высказался в поддержку мнения, согласно которому материя состоит из различных сочетаний так называемых четырех стихий (primary elements) — земли, воздуха, огня и воды. Эта идея легла в основу алхимии (alchemy).

Некоторые ученые продолжали придерживаться мнения, что материя состоит из атомов, но только в начале XIX века были получены экспериментальные данные, подтверждающие эту теорию. Английский химик и писатель Джон Дальтон (Dalton) проводил опыты с газами и изучал пути их соединения. Так, он обнаружил, что кислород (oxygen) и водород (hydrogen), образуя воду, всегда соединяются в одних и тех же пропорциях по массе (by mass). Другие ученые также сталкивались с подобными данными, но именно Дальтон впервые осознал их значение. Он сделал вывод, что вещества состоят из атомов, и что все атомы простого вещества (elementary substance) имеют одинаковую массу. При соединении простых веществ количества соединяющихся атомов находятся в определенной неизменной пропорции (invariable

proportion). Атомистика Дальтона (Daltonian atomism) объясняла, почему вещества соединяются в неизменной массовой пропорции (invariable mass proportion), а также явилась основой (basis) для детального изучения материи.

Вещества состоят из атомов, а из чего состоят атомы? Первые ключи к разгадке этой тайны появились в конце XIX века, когда исследователи изучали прохождение (flow) электричества через разрядные трубки (discharge tubes), содержащие разреженный (rarefied) воздух. Иногда стенки трубки излучали (emit) зеленый свет при подаче высокого напряжения (voltage) на две металлические пластины (plates) — электроды (electrodes). Свечение (glow) возникало при попадании невидимых лучей (invisible rays) от отрицательного электрода, или катода (cathode), на стенки трубки.

В 1890-х годах английский физик Дж. Томсон (Thomson) доказал, что эти катодные лучи (как их тогда называли) — не что иное, как потоки (streams) отрицательно заряженных частиц. Предполагалось, что эти частицы исходят из атомов, хотя их расположение внутри атомов оставалось неясным. Томсон высказал предположение, что атом может быть похож на рождественский пудинг, в котором большая, но легкая по массе положительно заряженная сфера усеяна (fill) многочисленными отрицательно заряженными частицами (электронами). Однако различные опыты по изучению строения атома доказали, что это — безусловно ошибочная (wrong) теория.

Notice these useful expressions of time.

At the beginning of the 19th century, ...	in the following years
...at the end of the 19th century	Until the late 1920s, ...
In the 1890s, ...	In about 1908, it became clear
in the mid-century	that...
in the early / mid / late 1860s	during the early years of
as early as 1890	during the following decade
in the latter part of the 17th century	By 1905, ...
in the years 1910–1916	After 1913, ...
in the period 1900 to 1910	By the 1920s, it was possible to
Throughout the century, ...	view...

7. Translate the following microtexts in written form.

Строение атома

В 1911 году Эрнест Резерфорд, британский физик, предположил, что центр атома имеет положительный заряд и от-

носителем большую массу, а вокруг ядра вращаются крайне легкие и отрицательно заряженные электроны.

Однако Резерфорд не осознавал, что обычно в ядре атома находятся как положительно заряженные, так и нейтральные частицы. Существование положительно заряженных частиц было признано в 1920 году, и они получили название «протоны». В 1932 году английский физик Джеймс Чедвик открыл незаряженные частицы и назвал их нейтронами.

Элементы

Любое вещество, в котором все атомы имеют одинаковое количество протонов, называется элементом. Число протонов в каждом атоме — атомный номер элемента.

Существуют 92 природных элемента, их атомы имеют от 1 до 92 протонов. К природным элементам относятся железо, ртуть и водород.

Во многих веществах атомы объединяются в группы, называемые молекулами. Так, газ водород состоит из молекул, каждая из которых содержит два атома водорода. Часто, однако, молекулы вещества состоят из атомов более одного элемента. Такие вещества называются соединениями. Например, вода является соединением, где каждая молекула состоит из двух атомов водорода и одного атома кислорода. Во многих молекулах насчитывается гораздо большее количество атомов. Некоторые белковые молекулы представляют собой сложные соединения из нескольких тысяч атомов.

Некоторые природные элементы встречаются только в соединениях. Так, натрий — это металл, настолько легко соединяющийся с другими веществами, что его нельзя обнаружить в чистом виде. Он широко известен в сочетании с хлором в виде хлорида натрия (sodium chloride) — поваренной соли (sodium / common salt).

Атомный вес

Протон и нейтрон имеют почти одинаковую массу, которая более чем в 1800 раз превышает массу электрона. Поэтому когда речь идет о массе атома, как правило, не будет ошибкой сослаться на его массовое число.

Атомный вес элемента, или его относительная атомная масса (relative atomic mass), обычно представляет собой среднюю массу смеси изотопов (isotopes), встречающихся в природе. Молекулярный вес вещества, или его относительная молекулярная масса, — это сумма атомных весов всех атомов в одной молекуле данного вещества.

Summarising

1. Read the text “The Four Forces” again. Note down the essential information. Use your notes as the basis for a summary (3–4 sentences). Mind that summarising is giving a brief account of the main points of the text.
2. Read the passage from “Six Easy Pieces” by Feynman again. Write a summary of the text (7–10 sentences).
3. Read through all the textual material of this Unit. Make up a list of dates and important events relating to the development of particle physics.
4. Sum up the information from all the texts and prepare a 7–10 minute talk on the subject “The discoveries in particle physics in the 19th–20th centuries”.

Grammar focus

Review of tenses: Passive forms

1. Study the tense table for the verb “analyze” in the third person singular in the passive.

	<i>Present</i>	<i>Past</i>	<i>Future</i>
<i>Simple</i>	it is analyzed	it was analyzed	it will be analyzed
<i>Continuous (Progressive)</i>	it is being analyzed	it was being analyzed	—
<i>Perfect</i>	it has been analyzed	it had been analyzed	it will have been analyzed
<i>Perfect Continuous (Progressive)</i>	—	—	—

Complete the tense table for the verb “test” in the passive in your notebooks.

2. Check whether you can use the passive tense forms correctly.
 - a) Answer the following questions in the **Past Simple Passive**.
 1. Did they agree upon the terms?
 2. Did he give a detailed description of the mechanism?
 3. Did you make a thorough analysis of the latest data?
 4. Did they object to your proposal?
 5. Did he refer to this book in his report?

b) Make up sentences describing what is being done now or around now.

1. This research program / discuss / widely in scientific literature.
2. A new powerful machine / construct / to accelerate particles to higher energies.
3. Some changes / make / in the experiment design at present.
4. Old equipment / replace / at several laboratories now.
5. Intensive investigation / carry out / in this field of research.

c) Make the following sentences passive.

1. They have lately published a new paper on this problem.
2. We have recently established new important facts.
3. They have done a very promising research this year.
4. In recent years we have made much progress in this area of physics.
5. They have considerably improved the technique in the last ten years.

d) Make up sentences using the Future Simple Passive.

1. In this paper (a brief account / give) of the data obtained.
2. In the next section (an attempt / make) to clarify this point.
3. At the next seminar (theoretical aspects of the problem / consider) in more detail.
4. Next time (all the disadvantages of this approach / discuss) in depth.

e) Make up sentences in the Present Simple Passive from the words given below.

1. In this paper special attention / give / to atomic-scale phenomena.
2. Much emphasis / place / on the importance of such studies.
3. Measures / take / to avoid the errors.
4. All of these requirements / meet / in a new series of experiments.
5. In our work readings / take / regularly.
6. High-precision measurements / make / with a special instrument.

f) Answer the questions in the Past Perfect Passive.

1. Had they completed all the experiments by the end of the year?
2. Had he submitted his paper for publication by the end of last month?

3. Had they already discussed the recommendations of the council when you arrived?
4. Had the committee produced its final report by that time?
3. a) Read the text and identify all the verb forms in the passive. Translate the text in written form.

The proton was discovered in 1914 by the British physicist Ernest Rutherford (1871–1937), and its name comes from the Greek word for “first” because at the time of its discovery it was the smallest object known to have a positive electric charge.

The neutron was discovered in 1932 by the English physicist James Chadwick (1891–1974). It carries no electric charge, either positive or negative. In other words it is electrically neutral, hence its name.

As early as 1911 Rutherford had shown that an atom contains almost all its mass in a very small region at the center, the nucleus. Once protons were discovered, it was realized that they are relatively massive particles and must be located in the nucleus. The number of protons varies from one kind of atom to another. The hydrogen atom has a single proton in its nucleus, the helium atom has 2, the lithium atom has 3, and so on — up to the uranium atom which has 92. Still more massive atoms have been prepared in the laboratory.

(From *The Collapsing Universe* by Isaac Asimov)

Mind the pronunciation of these words:

hydrogen	[ˈhaɪdrədʒən]
lithium	[ˈliːθiəm]
helium	[ˈhiːljəm]
uranium	[juˈreɪniəm]

- b) Put questions about the discovery of the proton and the neutron in the active and in the passive.
4. Put the verbs in brackets in the correct tense form, Past Simple, active or passive.

Starting in 1907, Rutherford (begin) an intensive study of scattering α particles by various targets. The scattered α particles (detect) by observing the flashes of light they (produce) upon reaching a zinc sulfide screen.

When the experiment (perform), it (find) that most of the α particles (scatter) through small angles, but a significant fraction (scatter) through much larger angles. And occasionally an α particle (stop) and (send) back out toward the source!

5. Pay attention to the following sentences in the passive. Name the tense forms.

Mention has been made of this effect. Был упомянут этот эффект.

Use is being made of these materials. Применяют эти материалы.

Reference was made to this law. Ссылались на этот закон.

Advantage will be taken of this fact. Воспользуются этим фактом.

Account is taken of this case too. Учитывается также и этот случай.

Collocations *to make mention of, to make use of, to make reference to, to take advantage of, to take account of* are typical of the scientific register.

6. Memorise the following verbs followed by prepositions and study the context in which they are used.

to approve of	одобрять
to arrive at	достигать чего-либо
to deal with	иметь дело с / рассматривать
to insist on (upon)	настаивать на
to refer to	ссылаться на
to rely on	полагаться на
to send for	посылать за

A new project **has** recently **been approved of**.

Недавно был одобрен новый проект.

This subject **will be dealt with** in the next chapter.

Эта тема будет рассматриваться в следующей главе.

This article is often **referred to**.

На эту статью часто ссылаются.

The equipment **was sent for** last week.

За оборудованием послали на прошлой неделе.

7. Identify the subject and the predicate. Translate the sentences into Russian.

1. Various parameters are measured in this way. 2. A lot of papers have been submitted to the program committee. 3. His report on unusual fluid dynamical behavior was well prepared. 4. The method under consideration is being intensively developed. 5. The effect has recently been predicted by our scientists. 6. Further details will be given in Chapter 2. 7. The resolution wasn't supported by the conference participants. 8. His papers are usually illustrated with slides. 9. This principle was introduced in the late 1970's. 10. The question hasn't been raised in literature so far. 11. The results of our research will be reported

at the next meeting. **12.** X-ray analysis has been widely used in science and technology for many years now. **13.** Such studies were described in literature a few years ago. **14.** The conference on semiconductors will be held at the end of September. **15.** Lasers have been used in research since the early 1960's.

8. Put the following words into the correct order.

- a) the / recently / results / been / discussed / have
- b) experiment / requirements / the / met / in / are / the
- c) made / the / was / experiment / week / last
- d) the / made / all / will / observations / be / directly
- e) has / been / good / made / progress / this / lately / field / in
- f) was / the / prize / awarded / Nobel / in / 1958 / he
- g) every / our / held / are / seminars / week
- h) laboratory / method / used / often / is / this / in / our

Word order

Some common variations on the basic word order: inversion

Grammatical inversion

- questions (general, special, alternative, and question tags)
- sentences introduced by *here* and *there*:

There is no discrepancy between the results. Между результатами нет расхождений.

- *there* can be used with a few verbs besides *be*: e.g. *exist, live, lie, remain, follow, arrive, come, rise, appear, seem*.

There remains one more question to be discussed here. Остается еще один вопрос, который здесь нужно обсудить.

There exist various forms of matter. Существуют различные формы материи.

Stylistic inversion for emphatic purposes

- conditional or *if*-clauses

Were he here...

Если бы он был здесь...

Had they arrived earlier...

Если бы они приехали раньше...

- sentences beginning with *never* (никогда), *little* (мало), *not only... but...* (не только..., но и...), *hardly / scarcely...* (едва..., как...), *no sooner... than...* (как только...)

Not only did he give good advice, *but* he carried out a series of experiments himself. Он не только дал хороший совет, но и сам провел серию экспериментов.

Only then did he understand his mistake. Только тогда он понял свою ошибку.

Never have I read such an interesting article. Никогда я не читал такую интересную статью.

• **do / does / did + infinitive** in the affirmative

It **did cause** some difficulties. Это все же (действительно) вызвало некоторые трудности.

• “fronting”

Items in a sentence can be put at the front for special emphasis.

An accelerator it certainly was. Конечно же, это был ускоритель.

Given in the table are the atomic masses of many nuclei. В таблице приведены значения атомных масс многих ядер.

Confirming this hypothesis is another piece of evidence. Эту гипотезу подтверждает еще один факт.

Of great importance is the starting material. Огромное значение имеет исходный материал.

1. Translate the following sentences with inversion into Russian.

1. Not only did he demonstrate that there was a fundamental unit of electric charge, but he also measured it accurately.
2. Only under very extraordinary conditions will a new element have a chance to survive the production process and land in a stable configuration — what we call the ground state.
3. Not only was he expert in the investigation of various luminescent effects, a common activity in physics laboratories of the 19th century, but he had studied the phosphorescence of some uranium compounds in particular.

2. a) Look through the following microtexts. Find sentences with stylistic inversion and translate them.

• In 1913, well before de Broglie postulated the wave nature of matter, Niels Bohr (1885–1962) proposed a model of one-electron atoms. The immediate purpose of the model was to explain the observed emission spectrum of hydrogen. Although the model was successful in this respect, it is now known to be quite incomplete and oversimplified. However, it does provide a very simple picture that we sometimes use to visualize complex atomic processes.

• Identifying the impact of physics research is important to many people and organizations, including research managers at companies, programme managers at funding agencies and, of course, physicists themselves. They are interested in who is citing the research, what impact it is having in various technical and development areas, and whether it is reaching the intended audience. They are also interested in whether the magnitude of the pay-off did justify the investment, what level of future investments can be justified, and where the new ideas are going.

b) Add emphasis to the sentences below.

Example: Bohr adopted Rutherford's nuclear atom model.

Bohr did adopt Rutherford's nuclear atom model.

1. He suggested that certain orbits are stable.
2. Bohr used a different approach.
3. These concepts survive today in our modern quantum description of nature.
4. The wave particle nature of matter provides the basis for these discussions.

c) Translate the sentences into English making use of emphatic "do".

1. Мы **действительно** недооценили (underestimate) результаты этого исследования.
2. Вскоре стало ясно, что прибору **все же** не хватает (lack) точности.
3. Они **на самом деле** используют современное оборудование при проведении этого эксперимента.
4. Ученые **фактически** нашли ответ на этот сложный вопрос.
5. К сожалению, эта проблема **действительно** создаёт (create) слишком большие трудности.

3. Read the extract from a "Physics Today" article (February 1999) about the plans of the American Physical Society (APS) for its 100th birthday.

a) Find the sentences with inversion and translate them into Russian.

The first of many centennial events will [sen'tenɪəl]
be the opening of a special Nobel Discover-
ies Exhibit in the congress center on Satur- [ɪg'zɪbrɪt]
day, 20 March, from 1:30–3 pm. The exhibit

will highlight the impact of discoveries that have won Nobel Prizes; it will be open for the duration of the centennial.

The rest of Saturday program will focus on the international physics community. Physics leaders from around the world will be in town to attend a meeting of the International Union of Pure and Applied Physics (UPAP), which ends on Saturday morning. Saturday afternoon, from 3 to 6 pm, APS will sponsor a special symposium on international science cooperation.

Following the symposium, there will be an international reception and banquet — [ˈbæŋkwɪt] honoring representatives of physical societies from many nations, from 7 to 10 pm at the Westin Hall. The reception and banquet are open to everyone who purchases a ticket.

Scheduled for the following morning, Sunday, 21 March, are a number of concurrent roundtables on such issues as international security and electronic publishing.

The scientific meeting will officially begin on Sunday afternoon with the opening centennial session and address by [əˈdres] D. Allan Bromley (Yale University) from 1 to 1:45 pm, followed at 2 pm by the first of roughly 800 technical sessions. In addition to the invited and contributed sessions on current research, the units of APS have organized a series of 34 centennial sessions, at which speakers will sur- [səˈveɪ]vey the highlights and preview the future of certain fields.

Monday morning program will open at 8:30 am with a plenary keynote address, [ˈpliːnəri] which APS has asked vice President Gore to deliver.

Immediately following, from 10:15 am to 12:30 pm, will be a panel discussion, with the participation of past Presidential science advisers.

From 4 to 6 pm on both Monday and Tuesday, 22 and 23 March, APS will hold special centennial plenary symposia. The featured speaker will be Steven Weinberg (University of Texas at Austin), talking about the physics of the very big and small; Harold Varmus (director of the National Institutes of Health), discussing the impact of physics on medicine and biology; Joel Birnbaum (Hewlett-Packard Laboratories), speaking about physics and the information revolution; Mary L. Good (Venture Capital), commenting on physics and technology; Richard Smalley (Rice University), talking about physics and materials; and Martin Klein (Yale University), reflecting on physics and American culture. [ˈkɒmənt]

On the social side, APS will host a welcome reception from 6:30 to 8 pm on Monday in the public space at the congress center. The following evening, from 6 to 8:30 pm, there will be alumni reunions sponsored by a large number of academic departments and national laboratories. Senior and retired members of APS can attend a special buffet breakfast from 7:30 to 9 on Tuesday morning. And any students attending the meeting are invited to mingle and partake of a complimentary lunch from 12:30 to 2 pm on Wednesday. [əˈlʌmnaɪ] [ˈbʊfeɪ]

On Wednesday, at a session from 5:15 to 7 pm, APS will honor some 35 individuals with prizes, awards and medals for their various contributions. Following the awards presentations, Andrew Sessler (University of California, Berkeley) will deliver his address as the retiring APS president.

Besides the talks in the scientific sessions, there will be opportunities to learn about certain topics in greater depth. The APS division of high polymer physics will be offering a short course on macromolecular

physics in biology and bioengineering on Saturday, from 8 am to 5 pm. On Sunday, 21 March from 9 am to 1 pm, APS will sponsor tutorials on five topics: magnetic force microscopy, cellular automata simulations [ɔ:ˈtɒmətə] with Mathematica, the physics of cold atoms, career choices in industrial and applied physics and key concepts in surface science.

During the centennial, APS will offer a job center, operated by the American Institute of Physics. The job center will be open from 9 am to 5 pm on Monday, 22 March, through Tuesday, 25 March. In addition, there will be two career and professional development workshops on Sunday, 21 March. One workshop, to be held from 8 am to 1 pm, will focus on the management problems of the technical person in a leadership role. The other, scheduled for 6:30–9 pm, will be a career workshop led by Peter Fiske (Lawrence Livermore National Laboratory), who has written a career guide for scientists.

Word list

centennial (<i>n</i>) — столетие	panel discussion — обсуждение
exhibit (<i>n</i>) — показ, экспозиция, выставка	вопроса группой специально отобранных людей
highlight (<i>n</i>) — основной момент, факт; (<i>v</i>) — показывать, освещать, выявлять	featured (<i>adj</i>) — прославленный
sponsor (<i>v</i>) — содействовать, руководить	reflect (<i>v</i>) — зр. размышлять
concurrent (<i>adj</i>) — одновременный	host (<i>v</i>) — проводить
address (<i>n</i>) — обращение, речь, выступление	reception (<i>n</i>) — прием
roughly (<i>adv</i>) — приблизительно	to purchase — покупать
survey (<i>v</i>) — исследовать, рассматривать	alumni (<i>pl</i>) — бывшие выпускники
preview (<i>v</i>) — предварительно рассматривать	retire (<i>v</i>) — уходить на пенсию
plenary session — пленарное заседание, пленум	reunion (<i>n</i>) — встреча
keynote address — вступительное слово	mingle (<i>v</i>) — зр. общаться
	partake (<i>v</i>) (of) — угощаться
	complementary (<i>adj</i>) — дополнительный
	tutorial (<i>n</i>) — семинар
	cellular automata (<i>pl</i>) — клеточные автоматы
	simulation (<i>n</i>) — моделирование
	workshop (<i>n</i>) — семинар, секция

b) Using the information from the text make up sentences with “there” as a formal subject in the Past Simple. Don’t forget about Subject – Verb Agreement.

c) Translate the following sentences from Russian into English using “there” as a formal subject.

1. Сейчас существует много доказательств в пользу (arguments in favour of) этой гипотезы.
2. Есть ряд причин (reasons), почему обсуждение этой проблемы надо отложить (be set aside).
3. Имеется некоторое расхождение (discrepancy) между предсказанными и экспериментальными значениями (values).
4. Остается немало нерешенных вопросов в этой области физики.
5. К сожалению, нет надежной (reliable) информации о природе этих объектов.
6. Есть ли какое-либо указание (evidence) на то, что в реакторе образовалась течь (have a leak).
7. Есть все основания полагать, что в ближайшие месяцы (in the coming months) ученые создадут более мощную установку.
8. Наблюдается ли какой-либо прогресс в области теоретических исследований (on the theoretical side)?
9. Мы надеемся, что выход из положения будет найден, и эксперимент продолжится.
10. В этой таблице содержатся недавно полученные данные.
11. Что находится в этой части лаборатории?
12. Были предприняты попытки модифицировать этот процесс.

Solving physics problems

1. **Do you know the difference between the terms “speed” and “velocity”? Read the explanation below and reproduce it in English.**

Many common words have different or more restricted meanings to physicists. In everyday usage, speed and velocity have the same meaning. However, in physics texts, a distinction is made between the two terms.

The speed is defined as the magnitude of the instantaneous velocity, so it is always positive or zero. An equivalent definition of speed is the distance traveled divided by the elapsed time.

The difference between the velocity and the speed is illustrated by the next example.

A man walks 10 km due east in 2 h. He then walks 10 km due west in 2 h. For the total 4-h trip, find his (a) average velocity; (b) average speed.

(a) After 4 hours, the man has returned to his starting point. Thus his displacement is zero, and his average velocity is

$$\bar{v} = \Delta x / \Delta t = (0 \text{ km}) / (4 \text{ h}) = 0$$

(b) The man has walked 10 km + 10 km = 20 km.

His average speed is the distance traveled divided by the elapsed time, (20 km)/(4 h) = 5 km h⁻¹ . .

2. Look through the constant acceleration formulae listed in the table below. Can you read them in English?

Table 1. Motion with constant acceleration

$v = v_0 + a \Delta t$	(1.1)
$\Delta x = v_0 \Delta t + \frac{1}{2} a (\Delta t)^2$	(1.2)
$\bar{v} = \frac{1}{2} (v_0 + v)$	(1.3)
$\Delta x = \frac{1}{2} (v_0 + v) \Delta t$	(1.4)
$v^2 = v_0^2 + 2a \Delta x$	(1.5)

3. The use of these formulae is illustrated by the following examples. Study them.

Example 1.

A car initially at rest at a traffic light accelerates at 2 ms⁻² when the light turns green. After 4 s, what are its velocity and position? Since we know the acceleration a , the elapsed time Δt , and the initial velocity $v_0 = 0$, we can use Eqs. 1.1 and 1.2 to find the velocity and displacement. Thus

$$v = v_0 + a \Delta t = 0 + (2 \text{ ms}^{-2})(4 \text{ s}) = 8 \text{ ms}^{-1}$$

$$\Delta x = v_0 \Delta t + \frac{1}{2} a (\Delta t)^2 = 0 + \frac{1}{2} (2 \text{ ms}^{-2})(4 \text{ s})^2 = 16 \text{ m}$$

After 4 s the car has reached a velocity of 8 ms⁻¹ and is 16 m from the light.

Note that we could also have found Δx from *Eq. 1.4*, using our result for v . Constant acceleration problems and physics problems in general can often be solved in more than one way.

Example 2.

A car reaches a velocity of 20 ms^{-1} with an acceleration of 2 ms^{-2} . How far will it travel while it is accelerating if it is (a) initially at rest; (b) initially moving at 10 ms^{-1} ?

(a) Here we know the initial and final velocities as well as the acceleration. Equation 1.5 contains these known quantities plus the displacement Δx . Solving for Δx , with $a=2 \text{ ms}^{-2}$, $v=20 \text{ ms}^{-1}$, and $v_0=0$, we find

$$\Delta x = \frac{v^2 - v_0^2}{2a} = \frac{(20 \text{ ms}^{-1})^2}{2(2 \text{ ms}^{-2})} = 100 \text{ m}$$

We could also have solved this problem by using $v = v_0 + a\Delta t$ to find Δt and then substituting the elapsed time into *Eq. 1.2* (Work out this solution as an exercise.)

(b) Proceeding as above but with $v_0=10 \text{ ms}^{-1}$,

$$\Delta x = \frac{v^2 - v_0^2}{2a} = \frac{(20 \text{ ms}^{-1})^2 - (10 \text{ ms}^{-1})^2}{2(2 \text{ ms}^{-2})} = 75 \text{ m}$$

The distance required to reach the desired velocity is shorter than in part (a) because the car is initially in motion.

Example 3.

A car accelerates from rest with a constant acceleration of 2 ms^{-2} onto a highway where traffic is moving at a steady 24 ms^{-1} . (a) How long will it take for the car to reach a velocity of 24 ms^{-1} ? (b) How far will it travel in that time? (c) The driver does not want the vehicle behind to come closer than 20 m nor force it to slow down. How large a break in traffic must the driver wait for?

(a) The time needed for the car to reach the velocity $v = 24 \text{ ms}^{-1}$ starting from rest satisfies

$$v = v_0 + a\Delta t, \text{ or } \Delta t = \frac{(v - v_0)}{a} = \frac{24 \text{ ms}^{-1}}{2 \text{ ms}^{-2}} = 12 \text{ s}$$

(b) Using *Eq. 1.2*, the distance traveled by the car in 12 s is

$$\Delta x = v_0 \Delta t + \frac{1}{2} a (\Delta t)^2 = 0 + \frac{1}{2} (2 \text{ ms}^{-2}) (12 \text{ s})^2 = 144 \text{ m}$$

(c) The vehicle behind is moving at a constant velocity $v_0 = 24 \text{ ms}^{-1}$, so $a = 0$. Using *Eq. 1.2*, in 12 s it moves a distance

$$\Delta x = v_0 \Delta t + \frac{1}{2} a (\Delta t)^2 = (24 \text{ ms}^{-1}) (12 \text{ s}) + 0 = 288 \text{ m}$$

Since the entering car travels 144 m in this time, the oncoming vehicle gains $(288-144)\text{ m}$, or 144 m . If it is to come no closer than 20 m , then the break in traffic must be at least $(144+20)\text{ m}$, or 164 m .

The car in this example reaches 24 ms^{-1} , or about $86\text{ km}\cdot\text{h}^{-1}$ ($54\text{ mi}\cdot\text{h}^{-1}$) in 12 s , which is a fairly brisk acceleration. A less powerful car would take longer to reach this speed and would require a longer break in traffic.

The above examples illustrate the procedures for solving constant acceleration problems and physics problems in general. We identify which quantities are known and which are to be found and determine the equation or equations relating these quantities. If necessary, we then solve algebraically for one unknown in terms of known quantities. Numerical values are usually best substituted in the final step rather than at an earlier stage. This tends to minimize the arithmetic labor and also facilitates checking for errors.

4. Now solve the problems below. Write the solutions in English and read them out.

1. A car traveling at 20 ms^{-1} hits a stone wall. The driver, who is wearing a shoulder harness and seat belt, moves forward 1.0 m as the car stops. Assuming her acceleration is uniform, find (a) her average velocity during the collision; (b) her acceleration.

2. In the television show "The Six Million Dollar Man" Colonel Austin had superhuman capabilities. In one episode he tries to catch a man fleeing in a sports car. The distance between them is 100 m when the car begins to accelerate with a constant acceleration of 5 ms^{-2} . Colonel Austin runs at a constant speed of 30 ms^{-1} . Show that he cannot catch the car, and find his distance of closest approach.

3. A lightning flash is seen, and 5 s later thunder is heard. Assuming they are produced simultaneously, how far away is the flash? (In air, sound travels at 344 ms^{-1} and light at $3.00\times 10^8\text{ ms}^{-1}$)

4. (a) A magazine article states that cheetahs are the fastest sprinters in the animal world and that a cheetah was observed to accelerate from rest to $70\text{ km}\cdot\text{h}^{-1}$ in 2 s . What average acceleration in ms^{-2} does this require? (b) The article also says the cheetah covered 60 m during that 2-s interval. How large a constant acceleration is implied by this statement? Does it agree with your result in (a)? (c) Accelerations substantially greater

than g are difficult for an animal or an automobile to attain, because there is a tendency to slip even on very rough ground with larger acceleration. Given this information, can you guess which number is wrong in the article?

Note that g is the acceleration of gravity near the surface of the earth; it is approximately equal to $g = 9.8 \text{ ms}^{-2}$.

(from *General Physics*)

5. Write at least two problems in English for the other students to solve.

Supplementary material for reading, translation and discussion

Why All the Fuss Over a New Element?

This article was published by Eric Scerri (UCLA) on August 28, 2013 in response to the recent confirmation of element 115.

Recently a new element has been in the news again. It's element 115 that doesn't even have a name yet. It was first created artificially a few years ago but only now is there enough experimental evidence on it for scientists to begin to take it seriously and to give it its name and its own symbols. The number 115 stands for the number of protons or positively charged particles that are packed into its nucleus. As atoms go, 115 is really very heavy and as a result this element is very unstable and only lasts for a fraction of a second before decaying radioactively into less heavy atoms. More familiar elements like oxygen, iron or gold have nuclei that contain 8, 26 and 79 protons respectively. The way in which heavy atoms like those of element 115 are created involves large experimental set ups, not altogether unlike the labs that recently succeeded in finding evidence for the much awaited Higgs particle.

One may wonder, "Does the new element have any commercial applications?" Well of course the answer is no, partly because it is so unstable. So what's the use in even trying to make it and why all the fuss about these new highly unstable atoms? The answer lies in the advancement of science. Chemists and physicists have now developed theories of stable atoms and have a pretty good understanding of how they function. This is not so true in the case of heavier atoms. So one of the reasons why

large amounts of money are invested into making these heavy elements is that they provide a testing ground for new theories of the stability of heavy nuclei. These theories combine quantum mechanics and the special theory of relativity, two of the most successful and far-reaching theories that have ever been developed in science.

In fact even heavier atoms than those of element 115 have been produced although most of them still lack experimental verification. The very next element after 115, or 116 not surprisingly, has already been verified and has even been given an official name. It is called livermorium after the Livermore facility in California where experiments to create it were conducted. Does any of this change the shape of the periodic table? Well not really because we already know in advance what the overall shape is and precisely where in the periodic table these new elements are expected to take their places.

Another point of interest and reason why these experiments are worth conducting is that heavy atoms do not always behave in the way that they are expected to according to the periodic table. But let me back-track a little. According to the periodic table all the elements that lie within a vertical column or group are supposed to share similar chemical and physical properties. And in most cases this is quite true. For example, the elements lithium, sodium and potassium in the first column on the left-side of the table are all soft white metals that are reactive and that can be cut with a knife.

But in the case of the new very heavy atoms everything is up for grabs. For example, the periodic table predicts that the element copernicium, which is number 112 in the table, should behave like cadmium and mercury since it lies in the same vertical column. However there is some evidence and some theoretical predictions that suggest that it may behave in an altogether different way and might be more like a highly unreactive noble gas. These are elements like helium, neon and argon that show no willingness to react with any other elements. So again by examining the behavior of very heavy atoms, scientists are able to test the limits of current knowledge and that will invariably trickle down to better science and better applications even if we cannot see precisely what that might be at the moment.

Is there a limit to how heavy atoms can get? The answer is still a matter of active research. According to some scientists the absolute limit lies at element 137. It can be shown from the cur-

rent theory that if an element heavier than this were created its electrons would have to move at speeds higher than the speed of light and as everybody knows that's physically impossible. Therefore there is no such thing as an atom with more than 137 protons, at least according to this theory. We will have to wait and see. At the moment the heaviest atom that has been created is the as yet unnamed element 118 with its 118 protons all jammed together in a tiny central nucleus around which 118 negative electrons are circulating. In addition experiments are underway in several labs in order to try to create atoms of elements 119 and 120.

What will the newly verified element 115 be called? At this stage it's anybody's guess. Maybe it will be named after the lab where its properties were verified, which was Lund in Sweden? Or maybe it will follow another naming convention, which is to name elements after famous scientists such as the case of einsteinium or bohrium or rutherfordium. Again we will just have to wait and see but one thing is for sure. Any person wanting to recite the name of all the elements will need to expand their vocabulary and will need to pronounce some strange new names to add to recent examples like darmstadtium (element 110), roentgenium (element 111) and flevorium (element 114).

(http://www.huffingtonpost.com/eric-scerri/element-115_b_3832687.html)

Discussion points

1. Why do scientists struggle to produce new artificial elements?
2. To what extent has the hunt for superheavy elements been successful so far?

Physics problems for fun

Think about possible answers to the problems below.

1. Heat stroke

If you ever mowed the lawn in the middle of summer as I used to do in Texas, you've probably wondered how your body stays as cool as it does. A significant amount of thermal energy is generated inside your body, up to 1400 kcal per hour during heavy physical exercise, and if that heat is not disposed of somehow, your body temperature could rise as much as 30°F per hour.

Of course, that would soon be fatal. How is the heat dissipated? Can you trace the path by which it is lost?

Mowing the lawn in the midday on a once-a-week basis was miserable, for I always got heat exhaustion, yet there are people who do this daily without ill effects. Somehow the body becomes accustomed to working in the heat. What exactly happens? The heat is generated at the same rate internally, so the dissipation mechanism must somehow change.

High temperatures in Texas were usually bearable because the humidity was so low. Why is it so much more uncomfortable in places with high humidity?

2. Turn or stop

It is hard to find any physics of a more real-world nature than that which involves your own death. For example, suppose you suddenly find yourself driving toward a brick wall on the far side of a T-intersection. What should you do? Use your brakes fully, without skidding, while steering straight ahead? Turn at full speed? Or turn while applying your brakes as well as you can?

Consider this question in parts. First, assume you can stop the car in time by braking and steering straight. Would turning instead also save you? Right now you'll probably want to think about this with ideal conditions. Later you can throw in the possibility of a skid, differences in road handling between front and rear tires, and brake fade. What if the straight-ahead option won't stop you in time? Should you bother turning, or are you doomed to an early death? If you were to find a large object in the road, would it be better to attempt a head-on stop or to try to steer around it? Of course, the answer will depend on the object's size.

Don't answer quickly in any of these cases, for even though you may be very experienced, your intuition may be wrong. If it is wrong, the question becomes far more relevant.

3. Snow avalanche

How can sudden warmings and mechanical vibrations trigger snow avalanches? Why do many avalanches occur at sunset when there is a general cooling rather than a warming? There are even claims that a skier's shadow may be enough to set off an avalanche. Why would this happen?

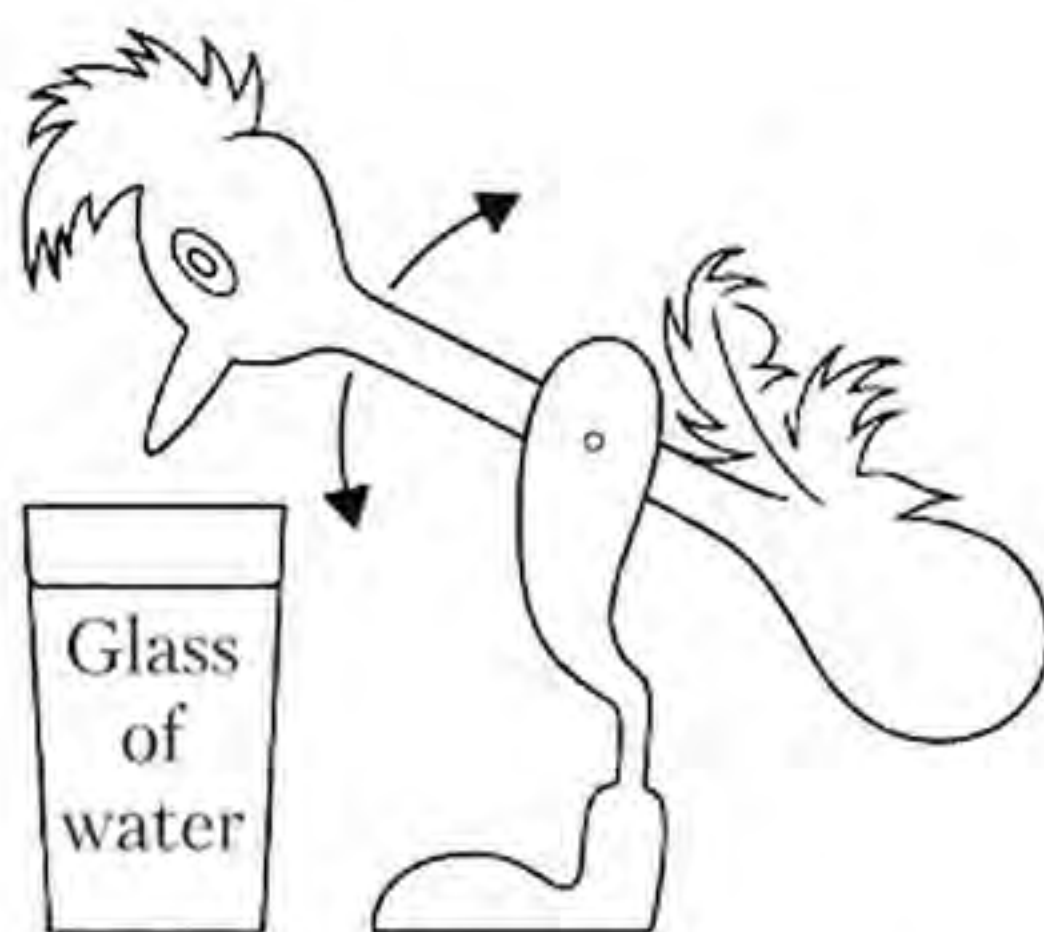
In a dry snow avalanche a huge cloud of snow particles precedes the slide, crashing down the mountain side at speeds up to 200 miles per hour with enough force to destroy large trees and move steel bridges. According to one story about a ski-

er caught in one of these snow slides, the skier and the slide reached the opposite slope with such speed that the trapped air was compressed and warmed and thus partially melted the snow. Within several minutes, however, the snow had refrozen, and when the rescue team reached the still-living skier, they had to saw him out.

4. Dunking bird

The dunking bird, which is probably the most popular of all physics toys, is a glass bird that rocks back and forth and “drinks” from a glass of water. You start the motion by wetting the head, after which the bird slowly begins to oscillate and eventually dunks its head into the water. The bird then rights itself and repeats the cycle without further assistance. As long as it keeps getting its head wet, it will continue to bob up and down. What makes it go?

Felt or
feathers
on head



Perhaps the dunking bird is a solution to next century's power needs. Just imagine — we erect a huge bird just off California, and as it continuously dunks its head into the ocean, it provides the entire West Coast with energy. This might lead to a dunking-bird cult, however, and we would all end up paying tribute by dunking in unison three times to the west each morning, so maybe we'd better just forget it.

(from *The Flying Circus of Physics* by J. Walker)

Unit III

FROM ANCIENT THINKERS TO GALILEO

Grammar	Infinitive. The Use of "it", "that", "one".
Skills	Cleft Sentences. Comparison Reading and Speaking. Summarising

Reading I

Pre-text exercises

1. Check whether you pronounce the words correctly.

ancient ['eɪnʃənt]	annihilation [əˌnaɪəˈleɪʃn]
antiquity [ænˈtɪkwəti]	encompass [ɪnˈkʌmpəs]
style [stɑɪl]	circulation [ˌsɜːkjʊˈleɪʃn]
appreciate [əˈpriːʃiət]	eternity [ɪˈtɜːnəti]
measure ['meɪʒə]	emerge [ɪˈmɜːdʒ]
genius ['dʒiːniəs]	period ['piəriəd]
Heraclitus [ˌherəˈklaɪtəs]	resume [rɪˈzjuːm]
Ephesus ['efɪsəs]	cyclic ['saɪklɪk]
survive [səˈvaɪv]	annual ['ænjʊəl]
variability [ˌvæəriəˈbɪləti]	heavenly ['hev(ə)nli]
conscience ['kɒnʃ(ə)ns]	invariance [ɪnˈvæəriəns]
irony ['aɪrəni]	reign [reɪn]
direct [daɪˈrekt; dɪˈrekt]	nevertheless [ˌnevəðəˈles]

2. Practise reading the following words and word combinations.

• • • • • •
 a) antiquity, culture, measure, appreciate, genius, Heraclitus,
 • • • • • •
 ancient, changeability, nature, fragment, survive, contradiction,
 • • • • • • •
 variability, conscience, irony, annihilation, relentlessly, nevertheless,
 • • • • • • •
 encompass, circulation, eternity, emerge, period, development,
 • • • • • • •
 organization, annual, heavenly, cyclic, invariance, totality, orbit

b) the level of knowledge, the style of reasoning typical of that culture, the scientific genius, Heraclitus of Ephesus, ancient Greece, thinkers of antiquity, the highest law of nature, contradictions and variability, to undergo changes, unstoppable stream, the chain of births and annihilations, the general changeability, the all-encompassing circulation, the creative game of Eternity, the thinkers of that period, the cyclic organization of phenomena, the surrounding nature, the annual cycle, temporary cyclic changes

Pre-reading task

Read the following extract from the book “The River of Time” by a brilliant Russian astrophysicist Igor Novikov. What do you know about ancient philosophers and the author of the book “About Nature” in particular? Try to work out the meaning of the new words from the context. Then study the Word list and read the text again for better understanding.

A visit to ancient times

As long as humankind exists, it will strive for new knowledge and will make new discoveries.

So many centuries separate us from antiquity that it is often very difficult to realize the level of knowledge of that time and the style of reasoning typical of that culture. It is therefore often almost impossible to appreciate the true measure of the scientific genius of a thinker in antiquity who made a bold step on the infinitely long road to uncovering the truth.

Heraclitus of Ephesus, a philosopher in ancient Greece who lived at the end of the 6th century BC, appears to have been one of the first thinkers of antiquity who set forth a belief that everything in the world changes and that changeability is the highest law of nature (all things are in process and nothing stays still). Heraclitus set out his view in the book *About Nature*, of which only a few fragments survived and reached us (*Cosmic Fragments*).

Heraclitus taught that the world is full of contradictions and variability. All things undergo changes. Time flows relentlessly, and everything that exists moves with this unstoppable stream. The skies move, physical bodies move, human's feelings and conscience move as well. “You cannot enter twice into one and the same river,” said he, “because its water is constantly renewed.”

Things come to replace other things. "The fire is alive through the death of the earth, the air is alive through the death of the fire, the water is alive through the death of the air, the earth is alive through the death of the water."

From the high ground of our current knowledge, we tend to look down with irony on the chain of births and annihilations described by Heraclitus. Nevertheless, he gave a very impressive picture of the general changeability of all things in time: "...everything is changing in the all-encompassing circulation in the creative game of the Eternity."

Science was just emerging in those distant centuries. The thinkers of that period had not yet formed the concept of directed progressive development. People rather observed the cyclic organization of phenomena in the surrounding nature. Day was replaced with night, to return again in the morning. One season was replaced with the next and was resumed at the end of the annual cycle. The motion of heavenly sources of light was cyclic too.

The idea of only temporary cyclic changes and the invariance of the totality of the existing world reigned in the minds of thinkers during many centuries. People believed that all phenomena change cyclically, returning "to their proper orbits".

Word list

realize (<i>v</i>) — осознавать, понимать	conscience (<i>n</i>) — сознание
appreciate (<i>v</i>) — оценивать, ценить; понимать	current (<i>adj</i>) — современный
measure (<i>n</i>) — мера, размер; критерий	chain (<i>n</i>) — цепь; вереница
bold (<i>adj</i>) — смелый	encompass (<i>v</i>) — охватывать
uncover (<i>v</i>) — раскрывать, обнаруживать	creative (<i>adj</i>) — творческий, изобретательный
appear (<i>v</i>) — появляться; казаться	eternity (<i>n</i>) — вечность
belief (<i>n</i>) — убеждение, мнение, вера	period (<i>n</i>) — период, эпоха
set forth (<i>v</i>) — излагать, формулировать	emerge (<i>v</i>) — появляться, возникать
still (<i>adj</i>) — неподвижный, спокойный	progressive (<i>adj</i>) — постепенный
view (<i>n</i>) — взгляд, мнение	resume (<i>v</i>) — возобновлять
contradiction (<i>n</i>) — противоречие	heavenly (<i>adj</i>) — небесный
variability (<i>n</i>) — изменчивость	totality (<i>n</i>) — всеобщность, зд. целостность
relentlessly (<i>adv</i>) — беспрерывно, неустанно	reign (<i>v</i>) — господствовать
undergo (<i>v</i>) — подвергаться	proper (<i>adj</i>) — свойственный; подходящий; правильный
	temporary (<i>adj</i>) — временный

Vocabulary work

1. Word building.

What do the following words from the text have in common?
What part of speech are they in the text? Do you know the meaning of these words?

level, time, style, measure, step, end, change, view, stay, book, reach,
flow, move, stream, fire, water, air, ground, look, form, cycle, mind, orbit,
current

What does the prefix “re-” mean in the words “replace”, “renew”?

In the text there are 5 words with negative suffixes. Name them.

2. Give English equivalents for the following Russian words from the text.

- 1) **nouns:** век, античность, уровень, знание, рассуждение, мера, гений, истина (правда), философ, изменчивость, закон, природа, убеждение, взгляд, противоречие, поток, сознание, ирония, цепь, эпоха (период), понятие, развитие, цикл, источник, явление
- 2) **verbs:** разделять, осознавать, оценивать, казаться, изменять(ся), излагать, уцелеть (сохраниться), достигать, подвергаться, течь, существовать, входить, заменять, обновлять, стремиться, описывать, возникать, наблюдать, возобновлять, господствовать, возвращать(ся), полагать (верить)
- 3) **adjectives:** трудный, типичный, невозможный, истинный, смелый, научный, древний, непрерывный, живой, существующий, впечатляющий, изобретательный (творческий), далекий, постепенный, окружающий, циклический, небесный, временный, годовой, свойственный, современный
- 4) **adverbs:** почти, бесконечно, только, непрерывно, также, постоянно, тем не менее, скорее, опять

3. Translate the following word combinations into English.

трудно понять, уровень знаний, манера рассуждать, невозможно оценить, истинный масштаб, научный гений мыслителя, сделать смелый шаг, открыть истину, прийти к убеждению, находиться в развитии, выразить мнение, полный противоречий, подвергаться изменениям, с высоты наших сегодняшних знаний, концепция постепенного развития, окружающая природа, целостность существующего мира, господствовать в умах мыслителей, в течение многих веков, возвращаться на круги своя

Interacting with the text

1. Checking the meaning

Refer to the text and paraphrase (explain in your own words) the following phrases.

the style of reasoning typical of that culture
from the high ground of our current knowledge
the cyclic organization of the surrounding nature
to reign in the minds of thinkers
to return "to their proper orbits"

2. Answer the following questions on the text.

1. What makes it difficult to appreciate the scientific genius of ancient thinkers?
2. Who was the first Greek philosopher to assert that changeability is the highest law of nature?
3. What did Heraclitus teach?
4. What does his well-known utterance (изречение) imply?
5. How did Heraclitus describe the chain of births and annihilations?
6. What were the limitations in the reasoning of ancient people as viewed from the high ground of our current knowledge?

3. Try to remember the correct words to be used in the blank spaces, without looking back at the text.

1. Heraclitus ... to have been the best thinker of antiquity who set ... a belief that everything in the ... changes.
2. Time flows ..., and everything that exists moves with this ... stream.
3. Things come to ... other things.
4. ..., he gave a very impressive picture of the general ... of all things in time.
5. Science was just ... in those distant centuries.
6. People ... observed the cyclic organization of phenomena in the ... nature.
7. One season was replaced with the next and was ... at the end of the ... cycle.
8. The motion of ... sources of light was cyclic too.

4. Now retell the text. You may use the questions on the text as an outline.

Reading II

1. Before reading the text check whether you know how to pronounce the following words.

Aristotle ['æriˌstɒtl]
 Plato ['plætəu]
 tremendous [trə'mendəs]
 imprint ['ɪmprɪnt]
 status ['stetəs]
 contribute [kən'trɪbjʊt]
 inherent [ɪn'hɪərənt]
 contemplative [kən'templətɪv]
 sphere [sfɪə]

primary ['praɪməɪ]
 ether ['iːθə]
 subject (*n, adj*) ['sʌbdʒekt]
 realm [reɪlm]
 uniform ['juːnɪfɔːm]
 subsequent ['sʌbsɪkwənt]
 uniquely [juːnɪkli]
 obstacle ['ɒbstəkl]
 progress ['prəʊgres; 'prɒgres]

2. Here is another extract from the book "The River of Time". Read quickly through the text and find the answers to the following questions.

1. What is Aristotle's contribution to science?
2. How did he regard physics?
3. What was his idea of the primary properties of matter?
4. What were the primary elements according to Aristotle?
5. What did his teachings about the Universe consist in?
6. Why did Aristotle's picture of the world become an obstacle to further progress in science?

Aristotle, one of the greatest scientists of ancient Greece, left a tremendous imprint on all later developments in science and philosophy. His writings gave a summary of the current status of the whole of science and greatly contributed to some of its fields.

In contrast to Plato¹, Aristotle rejected the notion of a non-material time-independent world of ideas. He believed that the world that we observe by vision and touch was real. Aristotle regarded physics as the

tremendous — огромный
 imprint (*n*) — отпечаток
 developments — события, явления
 contribute — делать вклад
 reject — отвергать
 notion — понятие, представление

¹ The famous idealistic Greek philosopher Plato (427–347 B.C.) taught that the world people observe and study is not the "true world" but is merely its external incarnation (воплощение). Both heavenly bodies and bodies on the Earth are but "pale shadows" of some ideal objects which constitute the true world: "These shadows are imperfect and changeable". Plato taught that the "true world" consists of abstract essentials (сущности) (he called them "ideas"). The "ideas", these "spiritual entities" (сущности), are impeccably (безупречно) perfect and unchangeable in principle. Ideas exist not in our material Universe, not in space and time, but in the ideal world of complete perfection and eternity.

science treating changing objects that exist in the real world. This distinguishes physics from mathematics which studies inherent, unchanging properties of numbers and shapes. Nonetheless, his physics remained a contemplative science.

According to Aristotle, the primary properties of matter are opposites: “warm” and “cold”, “dry” and “moist”; the primary elements are earth, water and fire. To these he added the most perfect element, the ether. Aristotle taught that the main elements — earth and water tend to move “downward”, towards the center of the Universe (this was his explanation of weight); we would say that they are subject to a force that pulls them down. Conversely, air and fire tend to rise up (in our language, we would say that a “lifting force” acts on them). It is of interest that the separation of the contents of the Universe into “physical matter” and “interaction forces” survived in physics to our days, even though they came to mean very different things.

Aristotle taught that the Earth was spherical and stationary, and that it was located at the center of the Universe. He taught that the Moon, the Sun and the planets are fixed to crystal spheres and revolve around the Earth along concentric circles. Their motion is driven by the revolution of the outermost (astral) sphere to which the stars made of ether are fixed. The region within the orbit of the Moon (“the under-moon realm”) is a region of various nonuniform motions. Everything beyond the orbit of the Moon (the “above-moon realm”) is the region of eternal, uniform perfect motion.

In subsequent years Aristotle’s teachings were canonized by the church; Aristotle’s words were treated as “uniquely true”; a ban on any changes in his picture of the world became an obstacle to further progress in science.

regard (*v*) — считать

treat (*v*) — изучать

distinguish —

отличать(ся)

inherent — прису-

щий, свойственный

contemplative —

созерцательный

according to — со-

гласно

property — свойство

perfect — совершен-

ный, идеальный

subject (*adj*) —

подверженный

conversely — наобо-

рот

contents — содержа-

ние

outermost — внеш-

ний

realm — сфера, об-

ласть

uniform (*adj*) — рав-

номерный

subsequent — после-

дующий

uniquely — исключи-

тельно

ban (*n*) — запрет

obstacle — препят-

ствие

3. Read the text again and entitle it.
4. Make an outline of the text in the form of statements.
5. Develop your outline into a summary.

Reading III

1. Read the text and comment on its title. Say why Copernicus' views were crucial to the development of science.

Make sure you know how to pronounce the following words.

Copernicus [kə'pɜ:nɪkəs]	rough [rʌf]
Renaissance [rɪ'neɪs(ə)ns]	chaotic [keɪ'ɒtɪk]
Medieval [ˌmedi'vɪl]	inertia [ɪ'nɜ:ʃə]
somber ['sɒmbə]	hurricane ['hʌrɪkən]
barrier ['bæriə]	argue ['ɑ:gju:]
ideal [aɪ'diəl]	Aristotelian [ˌærɪstə'tɪliən]
circular ['sɜ:kjʊlə]	treatise ['tri:tɪz; US: -tɪs]

The Copernican Revolution

The Renaissance that came to replace the somber Medieval centuries brought outstanding discoveries in natural sciences. This was the time when Nicolaus Copernicus (1473–1543) developed his theory which was to produce a dramatic transformation in people's view of the world. First of all, this new concept eliminated the impenetrable barrier between the terrestrial and the celestial. Before, everything celestial was a symbol of perfection, of eternity, and of ideals. Heavenly bodies were ideal, as was their uniform motion along circular orbits. This perfection was in opposition with the rough terrestrial matter and its chaotic irregular motion. Copernicus' model showed the Earth to be an ordinary planet which revolves, just as other planets, around the Sun. In our day, it is quite difficult to imagine to what degree a man's way of thinking had to be non-trivial to dare to claim at that time that the Earth was not stationary. The point here lies not only in the disagreement with ecclesiastical dogmas. Indeed,

somber — мрачный
 Medieval — средне-
 вековый
 outstanding — выда-
 ющийся
 dramatic — суще-
 ственный
 eliminate — устра-
 нять
 impenetrable —
 непроходимый,
 непреодолимый
 rough — грубый
 claim (v) — утверж-
 дать

Aristotle's teachings reigned in science, stating that force is constantly required to sustain any motion (science did not yet know anything about motion by inertia). It was assumed, as a result, that if the Earth revolved, this would affect terrestrial phenomena: the air would tend to stay behind, thus creating hurricanes on the rotating Earth; a body dropped off a tower would not fall to its foundation since the ground would fly away from under it, and so forth. This shows that Copernicus had to argue mostly against the Aristotelian misunderstanding of motion which was rooted in a long chain of centuries before him. There was another reason why these wrong notions were so difficult to overcome. Namely, people thought that no observations or experiments were needed to obtain knowledge about nature: it would be sufficient to think hard and reason by logical inference for the truth to be established. Using astronomical observations, Copernicus had not only created a new model of the Solar System but was in fact the first to challenge the dogmas of Aristotelian physics. He understood that everything on the Earth moving by must occur exactly as it would on the Earth at rest. Copernicus was very careful about publishing his results; he clearly recognized the contradiction with the church's teaching of the singular position of the Earth and man in the Universe. His treatise, <i>On the Revolution of Celestial Spheres</i>, was printed in 1543, not long before Copernicus' death. In fact, Copernicus had formulated his main conclusions long before the publication. At the beginning, Copernicus' teaching didn't cause any special worry for the Catholic Church. In the 17th century, however, when Copernicus' theory began to spread in Europe as actual rejection of the dogmas of the church, the treatise was placed into the "Index of Banned Writings" where it stayed for more than two centuries.	sustain — поддержи- вать assume — предпо- лагать affect — влиять hurricane — ураган argue — спорить root (<i>v</i>) — укорене- няться overcome — преодо- леть namely — а именно sufficient — доста- точный establish — устанав- ливать challenge (<i>v</i>) — оспа- ривать contradiction — про- тиворечие treatise — учение conclusion — вывод index (<i>n</i>) — каталог
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2. Read the text again and divide it into paragraphs. They are 6 in the original. Mind that a paragraph is a unit of thought concerned with the development of a single idea. It must refer to one controlling (key) idea. The sentence that expresses the controlling idea of a paragraph is the topic sentence.

Now identify the topic sentences from the text. Read them out.

3. Summarise the information about Copernicus' theory, highlight its strong and weak points.

Reading IV

1. Read the text about Galileo Galilei who was the first to show the importance of experimentation in science. Give titles to the paragraphs of the text.

Check whether you pronounce these words correctly.

Galileo [ˌɡælɪˈleɪəʊ]
substantiate [səbˈstænjɪeɪt]
superficial [ˌsjuːpəˈfɪʃl]
Einstein [ˈaɪnstəɪn]
identical [aɪˈdentɪkl]
horizontal [ˌhɒrɪˈzɒntl]
proceed [prəˈsiːd]

judgment [ˈdʒʌdʒmənt]
magnify [ˈmæɡnɪfaɪ]
Jupiter [ˈdʒuːpɪtəl]
protagonist [prəʊˈtæɡənɪst]
consequently [ˈkɒnsɪkwəntli]
notorious [nəʊˈtɔːrɪəs]
trial [ˈtraɪəl]

Galileo Galilei (1564–1642) developed a new understanding of physics, and formulated the first truly substantiated foundations of the science, which were later beautifully developed in the work of Isaac Newton.

substantiate — обосновывать, доказывать

Galileo made a great many important discoveries in science. The most important of these was his novel approach to natural sciences, his belief that to study nature one has first of all to set up carefully thought-out experiments. The world around us can only be understood by testing a hypothesis in experiments, by “asking questions of Nature”. Here he parted ways sharply with Aristotle, who assumed that the world could be understood by purely logical reasoning. Galileo also believed that superficial observations not accompanied by thorough analysis of data can lead to wrong conclusions.

foundations — основы

superficial — поверхностный

Taken together, this was the beginning of the modern method of studying nature. Einstein said that "the science relating the theory and experiment was actually born in Galileo's work". Indeed, Galileo's discoveries in physics were based on numerous experiments that he had conducted. Especially important is the discovery of inertia and inertial motion. This was Galileo's conclusion: "...horizontal motion is eternal since if it is uniform, then nothing weakens it, or slows it down, or destroys."

relate — связывать

especially — особенно

The law of motion by inertia discovered by Galileo is the basis of the principle of mechanical relativity. This principle states, for example, that regardless of whether a ship is at rest or sails at a uniform speed on smooth sea, all processes in a cabin proceed identically.

regardless of — независимо от
cabin — каюта

This discovery by Galileo Galilei was a scientific argument against the belief that the Earth is at rest in the Universe. Following Copernicus, Galileo stated: "Let us choose for the foundations of our cognition the concept that whatever be the motion of the Earth, the inhabitants of the Earth do not notice it as long as the judgments are based on things terrestrial."

following (smb) — вслед за
state (v) — утверждать
cognition — размышление
judgment — суждение

In 1608, Galileo heard that two spectacle lenses used together would magnify a distant object, and he soon built a series of telescopes of increasing magnifying power. He discovered that our moon has mountain ranges, that Jupiter has moons, and that the sun has spots.

magnify — увеличивать
moon — луна, спутник

Galileo firmly believed that Copernicus' teaching was true and became its passionate protagonist. Galileo's observations supported Copernicus' view that the earth is a planet which rotates daily on its axis and revolves annually about the sun. Consequently, he ran into serious difficulties with the authorities.

protagonist — сторонник
axis — ось
consequently — следовательно

After the notorious trial in 1633, he was made "Inquisition's captive" and kept under house arrest for the remaining 12 years of his life.

notorious — (печально) известный
trial — судебный процесс
captive — пленник

2. Ask all possible questions on the text. Let other students answer them.
3. List the most important discoveries made by Galileo.

Development

1. Look through the four texts again and complete the table below.

<i>The name of the philosopher / scientist</i>	<i>Contribution</i>

2. All the texts contain information about similarities and differences between the ideas of philosophers and scientists of the past and our current knowledge of the world. When similarities are identified, a comparison is made. A statement of contrast calls attention to differences.

The following words and phrases are used in statements of comparison and contrast.

Comparison

like — так; подобно
similar to — сходный с
as — как
likewise — так же, таким же образом, подобно
just as — точно так же, как
similarly — аналогично
in the same way — таким же образом
to resemble — походить
the same as — так же, как

Contrast

unlike — в отличие от
in contrast to/with — в противоположность чему-л., кому-л.
while — тогда как; хотя
although — хотя
but — но
conversely — наоборот
on the other hand — с другой стороны
rather than — скорее чем; вместо того, чтобы
nevertheless, however — однако, тем не менее

- a) Find statements of comparison and contrast in texts 1–4.
- b) Make your own statements of comparison and contrast on the basis of the factual material of the texts you have read.
Use these examples as a model:

Unlike other thinkers of antiquity, Heraclitus believed, just as we do today, that everything in the world changes.

While other thinkers of antiquity believed in the invariance of the world, Heraclitus set forth a belief that everything in the world changes.

As Copernicus Galileo stated that the earth is a planet which rotates on its axis.

3. Review the facts from texts 1–4 and speak about the major advances in science of that period.

You may make use of these phrases and add new ones.

- | | |
|---|--|
| 1. it is impossible to appreciate
to make a bold step
to uncover the truth
to set forth a belief
to set out one's view
to be full of contradictions
to undergo changes
to form the concept of
to reign in the minds of thinkers | 3. to produce a dramatic transformation
it was assumed that
to argue against smth
to be difficult to overcome
to obtain knowledge about nature
to establish the truth
to challenge the dogmas of
to formulate one's conclusions |
| 2. to leave a tremendous
imprint on
to give a summary of the current status
to make a contribution to
to regard physics as
according to
in contrast to
it is of interest that
to become an obstacle to further progress | 4. to develop a new understanding
of physics
to make important discoveries
to set up experiments
to test a hypothesis
to be accompanied by thorough analysis of data
to lead to wrong conclusions
to relate the theory and experiment
to be based on numerous experiments
to be the basis of the principle of |

4. Condense the information from texts 1–4 to 10–12 sentences. Write them down.

5. Translate the text about Archimedes (287–212 B.C.) at sight.

Archimedes [ˌɑːkɪˈmiːdiːz] was a mathematical and scientific genius [ˈdʒiːniəs] whose equal did not appear until Newton, 2000 years later. His relationship with King Hiero [ˈhaɪərəu] of Syracuse [ˈsɪrəkjuːs] afforded him both independent means and the attention of the man of power.

Archimedes is best remembered for his ingenious [ɪnˈdʒiːnjəs] machines, which captured the popular imagination, played a role in the wartime defense of Syracuse from the Romans, and in the end resulted in larger than life stories about him.

Many of the stories about Archimedes' inventions are distorted because he himself considered them beneath the dignity of the pure scientist and never left any written record of them. His written testaments include treatises on geometry, where he approached the foundations of calculus, equilibrium and the center of gravity, and hydrostatics.

The principle of hydrostatics that carries his name grew from a problem concerning the gold content of a crown made for Hiero. Archimedes was asked to determine whether the crown was pure gold or was adulterated with silver. After much thought, he realized while at the public baths that he could measure the volume of the crown very accurately by placing it in water and measuring the amount displaced. He then compared the weight of the crown with the weight of an equal volume of gold. This discovery apparently had at least two immediate results. The idea so excited him that Archimedes dashed home naked shouting "Eureka, eureka", and the goldsmith was executed because the crown was not pure.

Archimedes fully understood and demonstrated the importance of the lever (рычаг). He is said to have arranged a lever and pulley (шкив) system with which the king himself pulled a large ship onto the shore. His work on the lever and on the importance of the center of gravity laid much of the groundwork for modern mechanics.

(from *General Physics*)

6. Read the text and render it in English, either orally or in writing.

По прошествии трех с половиной веков многое видится не так, как это представлялось Галилею. Это относится и к различию между системами Птолемея и Коперника (Ptolemeic and Copernican Systems), и к вопросу об «истинности» движения Земли.

Трудно строить последовательную (consistent) систему мира, реально не опираясь на небесную механику (celestial mechanics). Парадокс заключался в том, что небесная механика Галилея в отличие от его «земной» механики была еще достаточно наивной и близкой к взглядам Аристотеля. Во-первых, он считал, что небесные тела движутся по инерции, не испытывая постоянно действующих сил. Для него не было приемлемым предположение (assumption) о дальнодействии, и, например, предположение о солнечном или лунном притяжении для земных объектов воспринималось как астрологический анахронизм (anachronism). Во-вторых, по Галилею, небесные

тела, двигаясь по инерции, совершают равномерные (uniform) вращательные (rotational) движения. Противоречие (contradiction) с «земным» принципом налицо!

Главным вопросом для Галилея был вопрос об истинном (абсолютном) движении Земли, об его экспериментальном доказательстве. Однако Галилей был еще далек от понимания относительного характера движения, о роли системы отсчета (frame of reference) при рассмотрении движения. Много для выяснения относительного характера движения сделал Гюйгенс (Huygens). Ньютон (в отличие от Гюйгенса) считал вращение абсолютным. В системах Птолемея и Коперника фигурируют разные системы отсчета: в одной покоится Земля, в другой — Солнце. Развитие механики показало, что удачно выбранная система необходима для выявления закономерностей движения. Главное достоинство системы Коперника — в возможности выявить законы Кеплера, которые, кстати, Галилей не принял.

Что касается астрономических наблюдений Галилея, то они открыли новую эру в астрономии. Особую роль сыграли при этом спутники Юпитера. Более полувека ушло на вычисление их периодов, которое пытался провести и сам Галилей.

Active Vocabulary

achieve approach challenge change	concept contribute develop discover	experiment law theory treat
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1. **achieve** [ə'tʃi:v] (v) выполнять; достигать; совершать; получать

to ~ understanding	достичь понимания
to ~ great progress	добиться большого успеха
to ~ one's aim / purpose / objective	добиться цели
to ~ experimental confirmation	получить экспериментальное подтверждение
to ~ good results	получить хорошие результаты

achievement [ə'tʃi:vmənt] (n) достижение

great / considerable / major / outstanding / remarkable / scientific ~	большое / значительное / главное / выдающееся / замечательное / научное достижение
an ~ in science	достижение в науке

2. **approach** [əˈprəʊtʃ] (v) приближаться; достигать

to ~ a problem	подойти к решению задачи
to ~ a subject (matter)	подойти к рассмотрению темы
to ~ a task	подойти к выполнению задания
the way to ~ / of ~ing	способ подхода
to ~ the subject (matter) for the first time	впервые подойти к рассмотрению темы

approach (n) подход, метод; доступ; приближение

an innovative / critical / promising / rational / sophisticated / valid ~ (to)	новаторский / важный, решающий / перспективный / рациональный / сложный, современный / обоснованный подход (метод)
to adopt / develop /	принимать (выбирать) / развивать (разрабатывать)
make an ~	создавать метод
to bring scientific ~s to the study (of)	вносить научные методы в исследование

3. **challenge** [ˈtʃælɪndʒ] (v) оспаривать, критиковать; конкурировать; бросать вызов

to ~ smb's conclusion / current thinking / assessment / doctrine	критиковать (оспаривать) чей-л. вывод / современную точку зрения (мнение) / оценку / доктрину
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challenge (n) задача; проблема, трудность; перспектива; вызов

to accept a ~	браться за решение проблемы
to face a ~	столкнуться с проблемой
to meet the ~	удовлетворять требованиям
to issue a ~	ставить задачу
to offer a ~	ставить задачу; открывать перспективу
the ~s facing researchers	задачи, стоящие перед исследователями

challenging (adj) перспективный, интересный, актуальный, важный, трудный, сложный

a ~ idea	перспективная (интересная) идея
a ~ proof	важное доказательство
a ~ problem	сложная и интересная задача; перспективная проблема

4. **change** [tʃeɪndʒ] (v) изменять(ся), превращать(ся)

to ~ drastically /
radically / slightly

изменяться резко /
коренным образом / незначи-
тельно

to ~ over time

изменяться со временем

to ~ the opinion / subject

изменить мнение / тему

to ~ in composition

измениться по составу

to ~ the variable from ... to

изменить переменную с ... на

to ~ to green

измениться на зеленый

to ~ 50°

измениться на 50°

to ~ one's mind

передумать

change (n) изменение, перемена

big / dramatic / drastic /
great / little / quick /
significant /
striking ~s

большие / существенные / рез-
кие / сильные / небольшие /
быстрые / значительные /
поразительные изменения

a ~ for the better

изменение к лучшему

a ~ in colour

изменение цвета

a ~ of sign

изменение знака

the rate of ~

скорость изменения

to bring about a ~

вызвать изменение

to make / introduce a ~

вносить изменение

to respond to a ~

отвечать (реагировать) на изме-
нение

to undergo a ~

подвергаться изменению / изме-
няться

A ~ takes place / occurs...

Изменение имеет место / проис-
ходит...

A ~ brings about...

Изменение вызывает...

changeability [ˌtʃeɪndʒəˈbɪləti] (n) изменчивость

5. **concept** [ˈkɒnsept] (n) идея, понятие; подход; принцип; ме- тод, методология; способ; процедура

a basic / complex / general /
key / valid ~

основное / сложное / общее /
ключевое / правильное понятие

an application / essence / validity /
feature of a ~

применение / суть / достовер-
ность / особенность идеи (под-
хода)

to accept / advance /
apply / define / develop /
examine / explore /
formulate / introduce /
present / make use of a ~

принимать / выдвигать / приме-
нять / определять / развивать /
изучать / исследовать / форму-
лировать / вводить /
представлять / использовать
понятие (идею, метод, прин-
цип)

to refer to a ~
 to turn to a ~
 to be based on a ~
 to consider a ~ in relation to
 This ~ emerged in 1995 / is appropriate to express /
 makes it possible to analyze /
 is essential for the understanding of / accounts for / will serve as
 a starting point for / postulates /
 is not totally clear cut / is exact enough / provokes dispute.

ссылаться на понятие
 обратиться к понятию
 основываться на понятии
 рассматривать понятие в связи с
 Этот принцип (подход, метод)
 появился в 1995 / подходит
 для выражения / позволяет
 проанализировать / важен
 для понимания / объясняет /
 послужит отправной точкой
 для / постулирует / не полностью ясен / достаточно точен /
 вызывает споры.

conception (*n*) понятие, представление; концепция; понимание

a clear ~
 a current ~
 a ~ about / of a theory

ясное представление
 общепризнанная концепция
 представление о теории

misconception (*n*) заблуждение, неправильное представление (понимание)

There is a common ~ that...

Существует общее заблуждение, что...

conceptual [kən'septʃuəl] (*adj*) понятийный, умозрительный, концептуальный

a ~ representation /
 scheme

концептуальное представление /
 концептуальный план

conceptually (*adv*) умозрительно, концептуально; в принципе, принципиально; согласно принятому представлению

Conceptually, the method is...

По идее, этот метод...

6. contribute [kən'tribju:t] (*v*) делать вклад; содействовать, способствовать; сотрудничать (в журнале)

to ~ greatly to
 to ~ suggestions on scientific questions
 to ~ to a discussion
 to ~ new information
 to ~ to a journal

много сделать для
 вносить предложения по научным вопросам
 участвовать в дискуссии
 сообщать новые сведения
 писать для журнала

contribution [ˌkɒntriˈbjʊːʃn] (*n*) вклад; участие; содействие; работа, статья, доклад; сотрудничество

an essential / important /
key / large / major /
outstanding / particular /
remarkable / significant /
valuable ~

to make a ~ to science

существенный / важный /
основной / большой / глав-
ный / выдающийся / особый /
замечательный / значитель-
ный / ценный вклад

внести вклад в науку

7. develop [dɪˈveləp] (*v*) развивать, разрабатывать; проявлять

to ~ a concept /
computer program /
hypothesis / method /
theory

to ~ gradually / rapidly

to ~ further / in detail

развивать (разрабатывать)

понятие / компьютерную про-
грамму / гипотезу / метод /
теорию

развиваться постепенно / быстро

разрабатывать дальше / подробно

development [dɪˈveləpmənt] (*n*) развитие, рост; совершенствование; разработка; проектирование; достижение; опытные работы; проявление (фото); вывод (формулы); *pl* события, явления

considerable / rapid ~

historical ~s

key ~

theoretical ~

to be engaged in ~ (of)

research and ~ (R&D)

research and ~ laboratories

значительный / быстрый рост

исторические события

основное достижение

теоретическая разработка

участвовать в разработке

научно-исследовательская работа

научно-исследовательские лабо-
ратории

to be under (intense) ~

accurate ~

(интенсивно) разрабатываться

точный вывод; точное решение

8. discover [dɪsˈklʌvə] (*v*) находить, открывать, обнаруживать; узнавать; раскрывать

to ~ a relation / value / general
principle

найти отношение / величину, зна-
чение / общий принцип

discovery (*n*) открытие

an important / significant /
critical ~

to make a ~

Our goal is the ~ of...

важное открытие

сделать открытие

Нашей целью является откры-
тие...

This ~ supplies evidence for / dem-
onstrates that / has given great
impetus to / will be relevant for /
caused a sensation.

Это открытие свидетельствует
в пользу / показывает, что /
стимулировало / будет акту-
ально для / вызвало сенсацию.

9. experiment [ɪk'sperɪmənt] (*n*) эксперимент, опыт; испытание; научная аппаратура

a laboratory / scientific / controlled ~	лабораторный / научный / управляемый эксперимент
~s with light	опыты со светом
~s under extreme conditions	эксперименты в экстремальных условиях
to carry out / conduct / do / make / perform an ~	проводить (делать) эксперимент
to repeat an ~	повторить опыт
to complete an ~	завершить опыт
to agree with ~s	согласовываться с эксперимен- тами
a preliminary stage of an ~	предварительная стадия экспери- мента
The ~ revealed that / indicates that / was used to determine...	Эксперимент показал, что / ука- зывает на то, что / проводился с целью определения...

experiment [ɪk'sperɪ,ment] (*v*) экспериментировать

experimental [ɪk,sperɪ'mentl] (*adj*) экспериментальный

recent ~ (and theoretical) studies	последние экспериментальные (и теоретические) исследования
to obtain ~ evidence	получить экспериментальные данные
~ set up	научная аппаратура
to require detailed ~ investigations	требовать детальных эксперимен- тальных исследований
~ observations	экспериментальные наблюдения
under these ~ circumstances	при этих экспериментальных условиях

10. law [lɔ:] (*n*) закон

a fundamental / general / physical ~	фундаментальный / общий / физический закон
the scaling ~	закон подобия
the ~ of gravitation	закон всемирного тяготения
the ~ of inertia	закон инерции
from Hooke's ~	по закону Гука
Newton's ~s	законы (динамики) Ньютона
Coulomb's ~	закон Кулона
to define / derive / discover / employ, follow, use / study / test a ~	определять / выводить / открыв- ать / применять, использо- вать / изучать / проверять закон
to obey a ~	подчиняться закону
to extend a ~ to other cases	распространять закон на другие случаи

The ~ governs / pertains to /
states / follows from / holds only
in certain situations / is derived
from the following principles.

Закон управляет / относится к /
гласит / следует из / дей-
ствует только в определенных
ситуациях / установлен исходя
из следующих принципов.

lawful (*adj*) законный

11. theory ['θiəri] (*n*) теория; теоретические знания

an accepted / complex / current /
relevant / valid ~

принятая / сложная / общепри-
знанная / актуальная / обосно-
ванная теория

the ~ of relativity

теория относительности

the inadequacy / significance /
limitations of a ~

несостоятельность / значение /
недостатки теории

according to a ~

согласно теории

in accord with a ~

в соответствии с теорией

to advance / apply / confirm /
develop / disprove / elaborate /
formulate / illustrate / present /
propose / put forward / support /
test / verify a ~

выдвигать / применять / под-
тверждать / развивать / опровер-
гать / разрабатывать / форму-
лировать / иллюстрировать /
представлять / предлагать /
выдвигать / обосновывать / про-
верять / подтверждать теорию

to put a ~ into practice
in ~

применять теорию на практике
теоретически

This ~ emerged in the 1960s / aims
at / is founded on / concentrates
on / relies on / neglects key
aspects of / ignores the role of /
predicts / maintains / holds /
has proved to be successful / has
received much criticism.

Эта теория появилась в 1960-х
годах / ставит целью / основыва-
ется на / сосредотачивается
на / опирается на / не учиты-
вает главные аспекты / игно-
рирует роль / предсказывает /
утверждает / имеет силу /
оказалась удачной / много
критиковалась.

theoretical (*adj*) теоретический

a ~ advance / aim / area / back-
ground / disagreement / impor-
tance / law / model / paper /
research / value / work

теоретический (-ая, -ое, -ие)
успех / цель / область / основы /
разногласия / важность /
закон / модель / доклад / иссле-
дование / ценность / работа

a stimulus for ~ research

стимул для теоретического иссле-
дования

to outline a ~ background

изложить теоретические основы

to rely on ~ methods

опираться на теоретические методы

to develop in ~ detail

детально разрабатывать в теоре-
тическом плане

theoretically (*adv*) теоретически

theoretician, theorist [ˌθiərəˈtɪʃn], [ˈθiərɪst] (*n*) теоретик

12. treat [tri:t] (*v*) изучать, анализировать; трактовать; рассматривать; обрабатывать; лечить

to ~ accordingly /
differently / identically

to ~ a subject / topic

to ~ the subject thoroughly

This article treats of the latest
developments in cosmology.

He treated the subject in detail.

трактовать соответственно /
по-другому / аналогично

изучать тему

рассмотреть предмет полно и все-
сторонне

В этой статье рассказывается
о последних достижениях
в космологии.

Он подробно осветил тему.

treatise [ˈtri:tɪz; US: -ɪs] (*n*) научный труд

a theoretical ~

a ~ on / upon a subject

to write a ~

теоретический труд

научный труд на тему

написать научный труд

treatment (*n*) исследование, анализ; метод, подход; решение

a complete / detailed /
experimental / up-to-date ~

to give / present / provide a ~

The above ~ shows that...

полное / детальное /

экспериментальное / современ-
ное исследование

дать анализ

Вышеупомянутый метод (анализ,
подход) показывает, что...

Vocabulary Work

1. Do you remember how the words from the Active Vocabulary function in the texts. Give the context in which they occur.

2. a) Study the table with adjective collocations.

considerable major remarkable outstanding	achievement	basic general key valid	concept
critical promising sophisticated valid	approach	essential important key major	contribution

dramatic drastic significant striking	change	outstanding remarkable significant valuable important critical	discovery
complex current relevant valid	theory	challenging complicated fundamental major serious	problem

b) Fill in the gaps with the suitable adjectives from the box.

1. A more _____ approach to the problem should be introduced.
2. It turned out to be a _____ achievement in computer science.
3. This is the most _____ problem in technology today.
4. _____ changes occur in the physical properties under these conditions.
5. The _____ concept provoked a sharp dispute among investigators.
6. This scientist made _____ contributions to theoretical physics.
7. _____ discoveries made by the researchers may affect current ideas about the evolution of the universe.
8. It is the main objective of scientists to provide _____ theories.

critical, key, challenging, dramatic, relevant,
sophisticated, remarkable, valuable

3. Consulting the Active Vocabulary

a) Translate the following word combinations from English into Russian and use some of them in the sentences of your own.

to achieve experimental confirmation, an outstanding achievement, to approach a subject matter for the first time, a sophisticated approach, to adopt an approach, to challenge current thinking, to face a challenge, a challenging problem, to change drastically, to change one's mind, striking changes, undergo a change, a valid concept, to refer to a concept, a current conception, to contribute to a discussion, to contribute to a journal, a valuable contribution, to develop a hypothesis, research and development, to be under intense development, a significant scientific discovery, experiments under extreme conditions, experimental set up, under these experimental circumstances, the scaling law, to obey a law, to extend a law to other cases, a relevant theory, limitations of a theory, in accord with a theory, to verify a theory, to develop in theoretical detail, to treat accordingly, to treat a subject, to provide a treatment

b) Give the English equivalents for the following Russian word combinations.

добиться большого успеха, добиться цели, значительное достижение, подойти к решению задачи, перспективный подход, критиковать чей-либо вывод, браться за решение задачи, важное доказательство, изменяться со временем, измениться на 50°, резкие изменения, вызвать изменение, вводить понятие, основываться на принципе, сообщить новые сведения, внести вклад, развиваться быстро, исторические события, участвовать в разработке, найти величину, сделать открытие, проводить эксперимент, получить экспериментальные данные, по закону Гука, открыть закон, согласно теории, несостоятельность теории, опровергать теорию, выдвигать теорию, теоретические разногласия, изложить теоретические основы, рассмотреть предмет полно и всесторонне, написать научный труд, дать анализ

4. Study the contexts in which words from the Active Vocabulary are used. Translate the sentences into Russian.

1. Great progress has been **achieved** in our understanding of this phenomenon. Such machines represent a considerable **achievement** in motor design. No improvement was **achieved** by applying this method.

2. No matter which of these **approaches** is followed, we shall not be able to get an immediate result. There must be several ways of **approaching** this knotty problem. We took an **approach** based on the newly developed theory.

3. The program offers both great **challenges** and unprecedented opportunities to engineers. These ideas should be challenged as strongly as possible to test their soundness. The **challenge** now is to explain why the experiment went wrong.

4. They have failed to find evidence for such **changes**. Our ideas have undergone a considerable **change**. The orange colour of the solution **changed** to green. When electric and magnetic fields are **changing** in time, they are, in fact, related to each other in a remarkable fashion.

5. Now we shall consider this phenomenon more fully in terms of present-day **concepts**. The device is simple both in **concept** and in construction. Some of our older **conceptions** are presently being revised, since they have come into conflict with new experimental findings.

6. The author's pioneer work initiated in the early 1970's **contributed** to our present knowledge of this most complicated phenomenon. The Organizing Committee is pleased to invite you to

contribute to one of the sessions. It is worth considering in this connection some other **contributions** to this field.

7. These two problems are really complicated and should be considered individually in the light of recent **developments** in quantum physics. Computer **development** has emerged from the explosion of scientific and engineering knowledge. The theory **developed** by these workers can hardly be regarded as a realistic one.

8. Michael Faraday **discovered** many of the fundamental laws of physics and chemistry, despite the fact that he had virtually no formal education. Along with the early **discoveries** of the basic physical properties of radiation, there was progress in understanding the biological effects of radiation as well. Devoting himself to scientific research for his entire life, he made many major **discoveries**.

9. The **experiment** yielded intriguing results. The first series of experiments was aimed at establishing a correlation between these two mechanisms. Recent theoretical and **experimental** advances in this area of physics are of great practical significance. This is a very attractive idea but not easy to test **experimentally**. The spacecraft is provided with more **experiment** than any satellite.

10. Kepler set down three **laws** for the motion of the planets around the sun. These phenomena are governed by special **laws**. All of the laws of mechanics which Newton derived follow from three basic principles, but these **laws** hold only in certain macroscopic situations. This calculation illustrates how to find electric field using Gauss's **law**.

11. Most **theorists (theoreticians)** consider this solution to be highly probable. In **theory** this type of reaction is possible. The authors put forward a new **theory** which can be regarded as quite explicit and clear-cut. We no longer use this **theory** because it has several weak points. Scientists question the value of the **theory** that involves extremely high energies and that cannot therefore be directly verified experimentally. Another curious feature of the **theory** is that the universe described by superstrings occurs in ten-dimensional space-time.

12. This is a big topic, and we have not attempted to **treat** it in full. Here we represent a complete **treatment** of these effects. The standard **treatment** of the problem is as follows. This group of mathematicians wrote a series of **treatises** that brought order and unity to mathematics.

5. Translate the sentences from Russian into English.

1. Еще не получено экспериментального подтверждения этой идеи. Мы провели серию опытов для достижения этой

цели. Мы надеемся достичь удовлетворительного уровня знаний в этой области. К сожалению (unfortunately), им не удалось добиться большого успеха.

2. В экспериментальных исследованиях этого явления можно выделить (distinguish), по крайней мере (at least), три подхода. Подходить к решению этой проблемы лучше всего с позиций (in the context of) теории относительности. Этот новаторский подход заслуживает внимания (deserve attention). Известно, что Коперник ввел научные методы в исследование окружающего мира.

3. Обработка (processing) информации представляет собой одну из сложнейших задач. Это предположение (assumption) недавно было подвергнуто серьезной критике. В конце концов мы решили взяться за решение стоящих перед нами проблем. Этот сплав (alloy) создан (develop), чтобы удовлетворять требованиям работы при высоких температурах. В статье рассматривается одна из наиболее важных и перспективных проблем в области нанотехнологий.

4. Вам не следует менять название (title) статьи. Изменения, приводящие к возникновению этого эффекта, заслуживают пристального внимания. Мы внесли некоторые изменения в методику (procedure) эксперимента. Эти процессы, вероятно, приведут к существенным изменениям в составе (composition) атмосферы.

5. Несомненно (undoubtedly), эта идея открывает перед учеными новые широкие перспективы (horizons). Раньше аналогичный (similar) подход едва ли можно было реализовать на практике. Невозможно переоценить (overestimate) значение этой концепции для современной физики. В этом случае удобно (convenient) ввести понятие энергии.

6. Был внесен важный вклад в изучение данного явления. Из-за недостатка времени (for lack of time) будут упомянуты лишь самые важные работы этого выдающегося ученого. Его монография, несомненно, является ценным вкладом в современную (current) научную литературу. Мы исследовали вклад каждого компонента в свойства раствора (solution).

7. Эти устройства (devices) интенсивно разрабатываются в течение последних двух лет. Ни одна система, разработанная в их лаборатории, не подводила (fail) нас до сих пор. Опытные работы привели к созданию (creation) новых устройств. Научно-исследовательские лаборатории этого института хорошо оборудованы (fully equipped).

8. Ученые придают (attach) большое значение этому открытию. В последние годы физики сделали много важных от-

крытий в этой области (field of research). Это открытие стимулировало (give impetus to) дальнейшее развитие астрофизики. Мы обнаружили, что эта теория не применима в ряде случаев.

9. Для проверки гипотезы мы провели ряд лабораторных экспериментов. Последние эксперименты показали, что эта величина остается неизменной на протяжении всего времени. Нам не хватало нужных инструментов для проведения опытов. Не так давно ученые сделали ряд предсказаний (make predictions), которые были подтверждены (verify) экспериментально.

10. По закону Гука мы имеем следующую формулу. Первый закон термодинамики (thermodynamics) будет детально рассмотрен в следующей главе (chapter). Многие задачи можно решить довольно легко, используя законы подобия. Общеизвестно, что законы Ньютона не действуют в субатомном мире. Эти физические принципы не содержатся (contain) в законе Кулона.

11. В 1933 году Ферми предложил теорию бета распада. По аналогии с (in analogy with) квантовой электродинамикой, теория взаимодействий кварков (quarks) и глюонов (gluons) называется квантовой хромодинамикой (quantum chromodynamics). Как теоретический, так и экспериментальный прогресс в этой области происходит довольно быстро (be rapid). Релятивистская теория движения электрона была выдвинута Дираком в 1928 году.

12. В практических целях (for practical purposes) более удобно рассматривать эти два случая отдельно (separately). Это явление изучалось как теоретически, так и экспериментально. Водяной пар (vapour) можно рассматривать как идеальный газ. Любое теоретическое рассмотрение проблемы является сложным (complicated). Эта тема довольно подробно рассматривалась в предыдущих (previous) главах. Его научные труды завоевали признание (gain recognition) много лет назад.

6. a) Read the text about the prominent physicist Enrico Fermi (1901–1954), paying attention to the context in which words from the Active Vocabulary are used.

Mind the pronunciation of the following words.

Fermi [ˈfɜːmi]

Pisa [ˈpiːzə]

origin [ˈɒrɪdʒɪn]

Pauli [ˈpauli]

Chicago [ˈtʃɪˈkɑːɡəʊ]

Columbia [kəˈlʌmbiə]

regime [reɪˈʒiːm]

hydrocarbon [ˌhaɪdrəʊˈkɑːbən]

capture [ˈkæptʃə]

target [ˈtɑːɡɪt]

Physics has become sufficiently specialized so that most physicists concentrate their efforts either on experimental work or theoretical calculations. Enrico Fermi was a notable exception to this rule. He made many important contributions of both types to physics.

Born in Rome, Fermi received his doctorate in 1922 from the University of Pisa for his research on X-rays. As a student he taught himself the new quantum theories that were being developed elsewhere but were not yet known in Italy. His efforts to explain these concepts to his fellow students and his professors helped to establish modern physics in Italy and also developed his abilities as a teacher.

After a brief period of study in Germany and Holland, Fermi returned to Italy in 1924 and became a professor at the University of Rome in 1926. In that year, he developed the theory of an ideal gas whose atoms obey the exclusion principle introduced in 1925 by Pauli. He found striking departures from the behavior predicted using classical physics, particularly at low temperatures and high densities. An example of such a Fermi gas is provided by the conduction electrons in a metal, which are nearly free and obey the exclusion principle. Fermi showed that many previously unexplained features of the electrical and thermal properties of metals were correctly predicted by this theory.

Turning his attention to nuclear physics, Fermi proposed a theory of beta decay in 1933, which in a slightly modified form remains our present-day basis for understanding this process. In 1934, he began a series of experiments in which he systematically bombarded a variety of targets with neutrons. Soon he discovered that placing water or a hydrocarbon between the source and the target increased the rate of production of artificial radioactivity. Fermi realized that the light atoms had absorbed some of the kinetic energy of the neutrons in a series of collisions and that the resulting slow neutrons were more readily captured by the target nuclei.

When the neutron is captured by a nucleus, its mass number A is increased by 1; if a subsequent β^- decay occurs, the atomic number Z also is increased by 1. Fermi and his collaborators therefore tried, in 1934, to go beyond the last known element by bombarding uranium ($Z=92$) with neutrons. They thought mistakenly that they succeeded in producing the first transuranic element ($Z=93$) when in fact they had caused uranium nuclei to fission. This was not realized until further work was done by Hahn and Strassman in Germany in 1939 that conclusively iden-

tified the fission products. Shortly before this discovery, Fermi and his family had fled the Fascist regime in Italy by traveling to Stockholm, where he accepted the Nobel prize, and then proceeded to New York. It was there that he learned of the work done in Germany.

Fermi immediately realized the importance of the discovery of fission and the possibility of a nuclear chain reaction. Working initially at Columbia University and later at the University of Chicago, he supervised the construction of the first nuclear reactor. When it was first operated on December 2, 1942, a now famous but then secret telegram announced that "the Italian navigator has entered the new world".

Fermi worked on the development of the atomic bomb during World War II, and then returned to academic life at the University of Chicago. In 1949, he joined several other leading scientists in opposing the development of the hydrogen bomb on ethical grounds. His postwar research centered on neutron studies, the properties of newly discovered particles called pi-mesons, and the origin of cosmic rays. Shortly after his death in 1954, the artificially produced element with atomic number 100 was named fermium in his honor.

(from *General Physics*)

Word list

absorb (*v*) — поглощать
capture (*v*) — захватывать
chain reaction — цепная реакция
collision (*n*) — столкновение
conduction electron — электрон
проводимости
decay (*n*) — распад
departure (*n*) — отклонение;
отступление
exclusion principle — принцип
исключения (запрета)
feature (*n*) — особенность, свой-
ство; признак

fission (*n*) — деление
hydrocarbon (*n*) — углеводород
navigator (*n*) — штурман
obey (*v*) — удовлетворять; под-
чиняться
origin (*n*) — происхождение
proceed (*v*) (to) — продол-
жать(ся); отправляться
subsequent (*adj*) — последующий
supervise (*v*) — следить; наблю-
дать
target (*n*) — цель, мишень

- b) Read out the sentences with the words from the Active Vocabulary of this Unit and translate them.**
- c) Write an outline of the text in the form of questions.**
- d) Retell the text making good use of the words and word combinations from the Active Vocabulary.**

Grammar Focus

Infinitive

1. Study the table with the forms of the Infinitive. Which forms do you think are most frequently used?

	<i>Active</i>	<i>Passive</i>
Indefinite	to make	to be made
Continuous	to be making	–
Perfect	to have made	to have been made
Perfect Continuous	to have been making	–

2. Review the functions of the Infinitive.

1. subject <i>To carry out</i> such experiments seems nearly impossible.	Проводить такие эксперименты кажется почти невозможным.
2. predicative Our task is <i>to do</i> this work properly.	Наша задача заключается в том, чтобы сделать эту работу должным образом.
3. part of a compound verbal predicate The question of the procedure is yet <i>to be settled</i> .	Вопрос о методе еще предстоит решить.
4. object We try <i>to minimize</i> the old disadvantages.	Мы стараемся свести к минимуму ранее имевшиеся недостатки.
5. attribute He was the first <i>to realize</i> the difficulty of the situation. The conference <i>to be held</i> in May is very important. There are some other phenomena <i>to be considered</i> .	Он был первым, кто осознал трудность положения. (Он первым осознал трудность положения.) Конференция, которая будет проведена в мае, очень важная. Существуют другие явления, которые необходимо рассмотреть.
6. adverbial modifier a) of purpose <i>(In order) to solve</i> this complicated problem we must work hard. The form of the equation should be simple so as <i>to be useful</i> for the calculation.	(Для того) чтобы решить эту сложную проблему, мы должны упорно работать. Форма уравнения должна быть простой, чтобы быть удобной для расчетов.

b) of result The problem is too intricate to <i>solve</i> (<i>to be solved</i>) in the near future. This method is not accurate enough to <i>give</i> reliable results. It is such a small error as <i>to be</i> easily <i>neglected</i>.	Проблема слишком сложная, чтобы ее можно было решить в ближайшем будущем. Этот метод недостаточно точен, чтобы дать (чтобы он мог дать) надежные результаты. Эта такая незначительная погрешность, что ею можно легко пренебречь.
7. parenthesis <i>To begin with</i>, no general method will be applied here. <i>To be sure</i>, all solutions to the problems are conditional. <i>To sum up</i>, the data presented by these authors are quite reliable.	Для начала следует сказать, что никакой общий метод здесь применяться не будет. Очевидно (безусловно), все решения этих задач являются условными. Подводя итог, следует сказать, что данные, представленные этими авторами, вполне надежные.

3. Identify the functions of the Infinitive and translate the sentences into Russian.

1. To construct an experiment of this kind is nearly impossible.
2. We attempted to carry out this investigation.
3. To perform this work one must have all the necessary equipment.
4. He was the first to focus attention on this type of reaction.
5. More evidence is needed to bridge the existing gap between experiment and theory.
6. In order to understand the procedure, consider the following analogy.
7. To sum up, there are two features of atomic structure, which we must bear in mind.
8. Under these circumstances the computer cannot be made to function.
9. The theory to be developed is not sufficiently detailed to give a complete description.
10. It is important to know the basic principle to be observed in the design and use of optical equipment.
11. The method to be followed has both advantages and disadvantages.
12. The same argument can be applied to understand the nature of this phenomenon.

Infinitive Constructions

1. The Objective with the Infinitive (Complex Object)
2. The Nominative with the Infinitive (Complex Subject)
3. The “for-phrase” with the Infinitive

Complex Object

1. a) Study the use of the Complex Object after different groups of verbs.

<i>Predicate</i>	<i>Examples</i>	<i>Translation</i>
1. to want to wish would like, etc.	They wanted <i>this problem to be discussed</i> at the seminar. We want <i>him to speak</i> about his experiments at the conference.	Они хотели, чтобы эту проблему обсудили на семинаре. Мы хотим, чтобы он рассказал о своих опытах на конференции.
2. to see to watch to hear to notice to observe, etc.	We heard <i>him deliver</i> a speech. We saw <i>our colleagues carry out</i> the experiment.	Мы слышали, как он произнес речь. Мы видели, как наши коллеги провели этот эксперимент.
3. to expect to think to believe to suppose to find to consider to mean, etc.	We expect <i>them to be involved</i> in the work. We know <i>the relationships to have been</i> thoroughly investigated. We find <i>this value to be</i> accurate enough.	Мы надеемся, что их привлекут к этой работе. Мы знаем, что эти взаимодействия тщательно исследовались. Мы считаем, что эта величина достаточно точная.
4. to allow to enable to cause to make to order, etc.	The use of the new method allowed <i>us to obtain</i> more accurate data. The discovery made <i>scientists revise</i> the old concept.	Применение нового метода позволило нам получить более точные данные. Это открытие заставило ученых пересмотреть старую концепцию.

Notice the translation of the verbs followed by the Complex Object.

assume — считать, полагать

consider — считать, полагать

choose — считать

expect — ожидать, надеяться, полагать

find — находить, обнаруживать, считать

hold — считать

suppose — полагать, предполагать

take — считать

think — думать, полагать

prove — доказывать

b) Translate the sentences into Russian.

1. We believe this conclusion to be erroneous.
2. Physicists expect this law to hold for all the cases.
3. I want you to send a copy of the paper.
4. We'd like you to join our research group.
5. We expect him to come to the same conclusion.
6. What made him recognize the significance of these studies?
7. They considered these results to be of great practical significance.
8. We think the exchange of ideas to be most stimulating.
9. We believe these ideas to have undergone a considerable change.
10. We made this reaction run at reduced pressure.
11. He proved this suggestion to be wrong.
12. There were some reasons to believe it to be the case.

c) Translate the sentences into English using the Complex Object.

1. Мы ожидаем, что у этих процессов будет много общего.
2. Мы полагаем, что наша теория будет подтверждена наблюдениями.
3. Мы считаем, что анализ данных даст ответ на этот вопрос.
4. Мы хотим, чтобы вы доложили о результатах своей работы на семинаре.
5. Я бы хотел, чтобы вы приняли участие в этой конференции.
6. Мы знаем, что этот ученый внес важный вклад в развитие ядерной физики.
7. Мы полагаем, что этот метод имеет несколько недостатков.

Complex Subject

2. a) Study the use of the Complex Subject.

<i>Predicate</i>	<i>Examples</i>	<i>Translation</i>
<i>in the Passive</i> to see to believe to suppose to expect to think to know to report to say, etc.	<i>This approach is expected to give better results.</i> <i>This argument has recently been shown to be wrong.</i> <i>This method was considered by the author to be inaccurate.</i>	Ожидается, что этот подход даст лучшие результаты. Недавно было показано, что этот довод неверен. Автор считал, что этот метод неточен.
<i>in the Active</i> to seem to appear to prove to happen to turn out	<i>They seem to be working at this problem now.</i> <i>He appears to have graduated from Moscow University.</i> <i>The theory proved to be valid.</i> <i>He doesn't appear to observe this rule.</i>	Они, кажется (по-видимому), сейчас работают над этой проблемой. Кажется, он закончил Московский университет. Теория оказалась достоверной. Он, по-видимому (кажется), не соблюдает это правило.
to be likely to be unlikely to be sure to be certain	<i>This question is likely to be discussed tomorrow.</i> <i>They are unlikely to follow our advice.</i> <i>He is sure to keep us informed about the further events.</i>	Этот вопрос, вероятно, будет обсуждаться завтра. Маловероятно (вряд ли), что они последуют нашему совету. Он, несомненно, будет держать нас в курсе дальнейших событий.

b) Translate the sentences into Russian.

1. This fact doesn't seem to raise any doubt.
2. These experiments are likely to throw some light on this complicated problem.
3. Lasers have proved to be indispensable in many fields of research.

4. These particles have recently been shown to have a complex structure.
5. This hypothesis has been found to disagree with experimental evidence.
6. This method doesn't seem to offer any advantages over that discussed above.
7. They can hardly be said to have discovered this phenomenon.
8. The conditions seem to have been poorly chosen.
9. He is sure to succeed in solving this problem.
10. This value is expected to be negligibly small.
11. In science, there always seem to be exceptions to the general rule.
12. There seem to be numerous data in recent publications concerning this mechanism.
13. The law in question is likely to account for this phenomenon.
14. As far as liquids are concerned this law is certain to hold.

c) Translate the sentences into English using the Complex Subject.

1. Известно, что полученные результаты обсуждались на семинаре.
2. Симпозиум, как ожидается, будет посвящен проблемам сверхпроводимости.
3. Оказывается, он закончил своё исследование два года назад.
4. Вероятно, на конференции будут обсуждать много важных вопросов.
5. По-видимому, их не удовлетворяют результаты исследования.
6. Маловероятно, что эта работа даст положительные результаты.
7. Несомненно, новый подход к проблеме будет весьма перспективным.
8. Вряд ли эту статью переведут вовремя.
9. Недавно было показано, что эта теория противоречит экспериментальным данным.

“For-phrase” with the Infinitive

3. a) Study the use of the “for-phrase” with the Infinitive.

For + Noun (Common Case) / Pronoun (Objective Case) + Infinitive

1. subject <i>For the reaction to occur</i> at very low temperature is quite possible. It is impossible <i>for you to repair</i> this device.	То, что эта реакция может происходить при очень низкой температуре, вполне возможно. Вы не можете отремонтировать этот прибор.
2. predicative It was <i>for us to complete</i> the experiment and <i>report</i> the results. The tendency was <i>for the reaction to proceed</i> rapidly.	Нам надлежало (мы должны были) завершить опыт и доложить о результатах. Тенденция заключалась в том, что реакция протекала быстро.
3. object They asked <i>for the data to be published</i> . We waited <i>for the discussion to begin</i> .	Они просили, чтобы эти данные были опубликованы. Мы ожидали начала дискуссии.
4. attribute The only conclusion <i>for him to make</i> was the following. This is the most complicated problem <i>for them to solve</i> .	Единственный вывод, к которому он мог прийти, (который он мог сделать) заключался в следующем. Это самая сложная проблема, которую они должны решить.
5. adverbial modifier of purpose <i>For this method to be valuable</i> it must be improved.	Чтобы этот метод был полезным, его надо усовершенствовать.

b) Identify the functions of the “for-phrase”. Translate the sentences into Russian.

1. For such suggestions to be of practical use they must be based on observation and experience.
2. For this effect to manifest itself the following conditions should be created.
3. For such an approach to be justified the final result must have a much higher degree of accuracy.
4. The conditions are favorable enough for the process to occur.
5. They waited for the preliminary conclusions to be made.
6. It is necessary for you to keep to the point.
7. It seems unreasonable for you to put off this work.
8. For us to go into great detail is unnecessary at the moment.
9. It was vital for us to solve that problem as quickly as possible.
10. There are many practical problems for us to solve in this field.
11. The most serious controversy for us to resolve was the following.
12. It was for them to give an expert analysis of the work.

c) Translate into English using “for-phrases”.

1. Вам надлежит проверить результаты эксперимента.
2. Недостаточно, чтобы они сняли показания прибора.
3. Для того чтобы наблюдение могло быть полезным, надо знать некоторые факты.
4. Температура была слишком высокой, чтобы реакция прошла удачно.
5. Единственный вывод, к которому мы можем прийти, заключается в следующем.
6. Для того чтобы эффект проявил себя, нужно создать соответствующие условия.

Functions of “it”, “that” and “one” in a sentence

1. a) Study the use of “it”.

It	Examples	Translation
1. Personal (личное) pronoun (a reference word)	We used another method, <i>it</i> was much better. He suggested repeating the experiment but I thought <i>it</i> would be useless.	Мы использовали другой метод, <i>он</i> был гораздо лучше. Он предложил повторить эксперимент, но я полагал, что <i>это</i> будет бесполезно.
2. Formal subject	<i>It's</i> cold today. <i>It's</i> easy to do this task. <i>It's</i> a pleasure to meet you. <i>It</i> seems that he knows the answer. <i>It's</i> useless doing this experiment.	Сегодня холодно. Это задание легко выполнить. Рад с Вами познакомиться. Кажется, он знает ответ. Бесполезно проводить этот опыт.
3. Formal object	I find <i>it</i> difficult to concentrate. I think <i>it</i> necessary to contact them.	Мне трудно сосредоточиться. Я считаю необходимым связаться с ними.
4. Introductory (вводное) <i>it</i> in emphatic constructions in cleft sentences	<i>It is</i> this topic <i>that</i> is under active discussion. <i>It was</i> prof. Brown <i>who</i> gave a lecture yesterday. <i>It was</i> yesterday <i>that</i> prof. Brown gave a lecture. <i>It was not until</i> the beginning of the 20th century <i>that</i> the new element was found.	Именно эта тема активно обсуждается. Именно профессор Браун читал вчера лекцию. Именно вчера профессор Браун читал лекцию. Только в начале XX столетия новый элемент был открыт.

It	Examples	Translation
5. Demonstrative (указательное) pronoun	What is <i>it</i> (this)? <i>It</i> (this) is a new device.	Что это? Это новый прибор.

b) Analyse the use of “it” in the contexts below. Translate the sentences into Russian.

1. In 1678, almost two centuries before Maxwell’s work on electromagnetic waves, Christian Huygens (1629–1695) proposed a wave theory of light. It is still very useful for understanding many properties of light and other waves, since it makes no reference to the physical nature of the wave phenomenon. To discuss Huygens’ idea, now called Huygens’ principle, it is useful to introduce the concept of a wavefront.

2. Glass fibers have been developed that have sufficiently low attenuation so that they can transmit light for many kilometres. This makes it feasible to construct optical communications systems. In principle, the higher the frequency of a wave, the more data it can transmit per second.

3. The general theory of relativity was published in 1916. It predicted the deflection of light in a gravitational field, which was confirmed in England in 1919.

4. Despite the great success of Maxwell’s electromagnetic wave theory in predicting phenomena involving light, it failed to describe correctly some processes in which light is absorbed or emitted by matter.

5. It is primarily the thermonuclear conversion of hydrogen into helium and helium into heavier elements with a resulting release of energy that causes the stars to shine.

6. It is scientific research that is the cornerstone of a successful knowledge-based economy.

7. Advances in space technology and instrumentation now make it possible to determine the composition of samples of matter from elsewhere in our galaxy, the Milky Way.

8. Mayer also suggested that energy can be neither created nor destroyed. His work was largely ignored, and it was not until the work of James Prescott Joule (1818–1889) several years later that the equivalence of heat and energy was accepted.

9. It is interesting to note that the use of Archimedes’ principle by itself does not fully account for the variations in the thickness of the crust. Nevertheless, it describes the observations

well enough so that when one finds places where its predictions fail, it is worth further study to examine why this happens.

10. It was only in the early years of the 20th century that indirect methods began to be used for the evaluation of greater distances.

c) Translate the sentences from Russian into English.

1. Лучше сосредоточить (focus) наше внимание на основных (basic) принципах.
2. Вес тела — это гравитационная сила, которая на него действует.
3. Именно его новаторская (pioneer) работа способствовала дальнейшему прогрессу в этой области.
4. Бесполезно пытаться изменить что-либо сейчас.
5. Мы считаем разумным предположить, что скоро будет получено экспериментальное подтверждение этой гипотезы.
6. Он сделал важное открытие, но его, очевидно, забыли.
7. Именно по этим причинам нам пришлось отказаться от идеи создания установки в ближайшие месяцы.
8. Общеизвестно, что этот закон не работает (hold) в ряде случаев.
9. Только в 1970 году астрономы получили возможность наблюдать это редкое явление.

2. a) Study the use of “one”.

One	Examples	Translation
1. Numeral	There is only one way of solving this intricate problem.	Есть только один способ решения этой запутанной проблемы.
2. Indefinite pronoun	One should keep in mind that the test is extremely dangerous.	Надо помнить, что это испытание чрезвычайно опасно.
3. Substitute (слово-заменитель) for nouns	This idea is more challenging than the one you suggested earlier.	Эта идея более перспективная, чем та , которую вы предлагали ранее.

b) Translate the sentences from English into Russian.

1. When one is engaged in research, one often has to use intuition and imagination.
2. One such example is the discovery of laser.
3. One generally assumes that the test of all knowledge is experiment.
4. Newton solved three problems in one stroke.

5. The behaviour departs from the one we observed at lower energies.
6. Such errors are approximately one part in a thousand.
7. The internal angular momentum is distinct from the external one.
8. This device is identical in design to the one described earlier.

3. a) Study the use of “that”.

That	Examples	Translation
1. Demonstrative pronoun тот, та, то	That paper was presumably published a couple of year ago.	Вероятно, та статья была опубликована два года назад.
2. Conjunction что; то, что	The theory holds that these processes go on concurrently. That the research will require much effort is not doubted.	Согласно теории, эти процессы происходят одновременно. То, что исследование потребует много усилий, не подвергается сомнению.
3. Relative (относительное) pronoun который (-ая, -ое, -ые)	They suggest a project that will have a positive impact on our understanding of the phenomenon.	Они предлагают проект, который положительно скажется на нашем понимании этого явления.
4. Substitute	Their research is by no means more important than that of your team.	Их исследование ни в коей мере не является более значимым, чем исследование вашей группы.

b) Translate the sentences from English into Russian. Identify the usage of “that”.

1. Since 1976, the company has presented awards to people breaking new ground in areas that advance knowledge.
2. The Carnegie University team believes that the high density of the new material will make it an attractive future source of energy.
3. The range of physics that is being explored with these simple plasma systems is surprisingly broad and touches on issues of interest to plasma physics, atomic physics, condensed matter physics and fluid dynamics.
4. He points out that the results are interesting, but that no strong conclusions can be drawn about agreement or disagreement with the standard model.

5. Irish astronomers are slowly becoming frustrated by the lack of interest that their government has in funding basic research in their subject.

6. A number of well known theoretical physicists are unanimous in the opinion that the relation is exact.

7. Physicists are a step closer to building quantum circuits that are based on the flow and movement of cold atoms, rather than electrons on semiconductor chips.

9. Further exploration of that intricate problem met with unprecedented success.

10. We know from experience that e-mail is a very useful Internet service.

11. He noted with regret that the world is slow to catch on to new ideas.

12. The machine has never been used for any purpose other than that for which it is intended.

13. Astronomy is unique in physical sciences in that one is permitted to look, but not to touch.

Cleft Sentences

1. **Skim the text and find the emphatic construction. Translate the cleft sentence in which it is used.**

As many other great ideas, the theory of gravitation had its precursors. For instance, Giovanni Borelli concluded that there was mutual attraction between all bodies in the Universe; also, he conjectured that as planets revolve around the Sun, its attraction balances out the centrifugal forces that were discovered by Huygens. Another contemporary of Newton, Robert Hooke, came to the conclusion that the force of attraction between bodies is universally proportional to the squared distance separating the bodies. We believe, nevertheless, that it was Isaac Newton who created the theory of gravitation.

2. **Read the microtexts and emphasise the italicised words using the "it is ... that / who" construction.**

Text 1

Archimedes (287 — 212 B.C.) was one the world's great experimental scientists in the modern sense of the term. He devoted most of his study to *mechanics and mathematics*, working out solutions to important problems connected with pulleys, levers, inclined planes, and floating bodies.

Text 2

While staying in Woolsthorpe in 1665–1667, Isaac Newton was not only occupied by the problems of gravitation; he also worked in mechanics, optics and mathematics, in which he made fundamental discoveries.

In the post-Woolsthorpe period, until the 1680's he was mostly interested in *optics and chemical experiments*. *In the mid-1680s* he wrote and published the main accomplishment of his life: the famous *Principia*. *This treatise* summarized the fruits of thinking in his Woolsthorpe period and the results of the subsequent development of the ideas conceived at that time.

3. Translate the sentences from Russian into English.

1. Именно эти данные нуждаются в дополнительной проверке (verification).
2. Именно самые важные факты нужно выбирать из большого объема (a large body) сведений.
3. Именно эта теория должна предсказать результаты новых исследований.
4. Именно на этой точке зрения настаивал ваш коллега.
5. Именно у этого метода есть ряд недостатков.
6. Именно Планк впервые предложил квантовую теорию в 1901 году.
7. Именно этот результат мы пытались получить в течение последних нескольких лет.
8. Только в конце XX века удалось проникнуть в существо (get to the root) этой сложной проблемы.

Degrees of Comparison

1. Form the comparative and superlative of the following adjectives. When do you use *-er* / *-est* and *more* / *most*?

great	short	simple
valid	rapid	clever
significant	promising	modern
large	valuable	useful
important	unique	common

Mind that some two-syllable adjectives can have two types of comparison:

narrow, happy, simple, polite, clever, common, quiet, etc.

2. Make sure you know the irregular forms. Complete the chart for adjectives and adverbs.

<i>Positive</i>	<i>Comparative</i>	<i>Superlative</i>
bad / badly	worse	?
good / well	?	best
many / much	more	?
little	less	?
far	?	farthest / furthest
near	nearer	? / ?
late	? / ?	last, latest
old	? / ?	oldest / eldest

Do you know the difference between “farther” and “further”, “next” and “nearest”, “later” and “latter”, “last” and “latest”?

The following intensifiers can be used with comparison of adjectives and adverbs

slightly a little	better	несколько (немного) лучше
much a great deal	more useful	гораздо (значи- тельно) более полез- ный
by far	the best	гораздо (значительно, намного) лучше

Note: It is most interesting. Это очень интересно.
It is a most interesting review. Это весьма (очень, в высшей степени) интересный обзор.

3. Study the following sentences with comparative constructions.

as... as...	
This report is <i>as interesting as</i> the previous one.	Этот доклад <i>такой же интересный, как</i> и предыдущий.
He introduced this concept <i>as early as</i> 1937.	Он ввел это понятие <i>уже в</i> 1937 г.
The temperature <i>ran as high as</i> 40°C.	Температура <i>доходила до</i> 40°C.
The reaction <i>continued for as long as</i> 10 hours.	Реакция <i>продолжалась</i> 10 часов.
The distance in this case <i>may be as much as</i> several microns.	В этом случае расстояние <i>может достигать</i> нескольких микронов.
This <i>amounts to as much as</i> 12% of the total mass.	Это <i>достигает</i> 12% от общей массы.
The build-up <i>may run as high as</i> 0.5 inch.	Наращивание <i>может составить</i> 0,5 дюйма.

not as / so... as	
This result is <i>not so important as</i> that one. These experiments were <i>not as successful as</i> the others.	Этот результат <i>не такой важный, как</i> тот. Эти эксперименты были <i>не такими успешными, как</i> все остальные.
comparative + "than"	
We will examine this phenomenon <i>more rigorously than</i> our predecessors.	Мы исследуем это явление <i>более тщательно, чем</i> наши предшественники.
"the" + comparative + "the"	
<i>The harder</i> you work, <i>the better</i> results you get.	<i>Чем больше</i> вы работаете, <i>тем лучше</i> результаты вы получаете.
"the" + superlative	
This is <i>the least important</i> fact. These are <i>the most general</i> requirements imposed on precision instruments.	Это <i>самый незначительный</i> факт. Это <i>самые общие</i> требования, налагаемые на точные приборы.
comparatives joined by "and"	
Computers are becoming <i>more and more complicated</i> . Such measurements are <i>less and less common</i> .	Компьютеры становятся <i>все более сложными</i> . Такие измерения все <i>менее обычны</i> .
Pay attention to the translation of the following word combinations	
twice as much as four times as long as three times as high as ten times as much as half as much / many as	в два раза больше в четыре раза длиннее в три раза выше в десять раз больше вдвое меньше

4. Translate the sentences into English. Make adequate use of comparative constructions and word combinations.

1. Луч радиолокатора (radar), направленный вертикально вверх, позволил английским энтомологам (entomologists) определить, что насекомые (insects) залетают на высоту до 1200 метров.

2. Разработан электрохимический способ получения титана (titanium [taɪ'teɪniəm]), который в семь раз продуктивнее общепринятого (commonly accepted) метода и позволяет снизить стоимость (cost) металла в три раза.

3. Новый суперкомпьютер ИБМ занимает площадь двух баскетбольных площадок и выполняет в секунду 12 милли-

ардов операций. Эта машина в 1000 раз мощнее той, которая в 1997 году победила Гарри Каспарова.

4. По новым данным, в непосредственной близости от Земли обращаются около 1100 астероидов (asteroids).

5. Астрономы обнаружили еще четыре спутника (moons) Сатурна. Поперечник крупнейшего из них — лишь 50 километров. Скорее всего (most likely), это астероиды. Таким образом, общее число спутников Сатурна — 22.

6. Английские физики получили самую низкую температуру, не дойдя (stop short of) до абсолютного нуля всего на несколько миллионных долей градуса.

Supplementary material for reading, translation and discussion

Was Aristotle (384 — 322 B.C.) the first physicist?

Ever since Galileo attacked Aristotle's view of the world, the Greek philosopher's ideas have been regarded as a barrier to scientific progress. Michael Rowan Robinson¹ disagrees.

In the spring of 1998 I found myself standing on the stones of the Lyceum of Aristotle in Athens. It was strange to think that for two millennia no-one had stood on this spot and known the significance of the place. The location of the Lyceum — the world's first university — had been roughly known to archaeologists, but the unexpected discovery of it by Ephie Ligouri in 1997 was without doubt one of the most momentous classical discoveries of modern times.

By persistence and immense good fortune, I found myself being shown round the site — which was at the time still closed to the public — by Ligouri herself. The site is large — some 50 metres across and consists of the exposed foundations of a large building sitting on bedrock. When Ligouri realized that she had stumbled on a “gymnasio” — a building given over to physical exercise and training — she knew at once that it must have been the Lyceum. It was not exactly in the location traditionally assigned to the Lyceum, but the site satisfied all known requirements: to the east of the city walls and on the banks of the river Iliso.

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Archaeologists were still working on the site when I visited. However, the future of the site, which is intended to be the venue for a museum of modern art, remains uncertain. The dig was an emergency one before concrete foundations were to be poured onto the site. I hope that these foundations will never be laid. Given its significance in the history of western culture, this is a building that must be preserved for posterity.

Aristotle's Lyceum provided the world's first comprehensive set of courses on all aspects of knowledge. Although the little room where Aristotle probably taught had space for perhaps just 10 students, the scope of the courses that he gave there, which miraculously survive today in some 30 books of his lecture notes, was phenomenal. It is hard to believe they were written by a single person.

Aristotle had an extraordinary range of interests and learning. His courses included philosophy, logic, astronomy, physics, biology, meteorology, poetry, drama, ethics, politics, psychology and economics — in fact, many of the subjects of a modern university. Some of his biological insights were not rediscovered until the work of Cottlob Frege in the early part of the 20th century.

Aristotle's ideas dominated western science and philosophy for nearly 2000 years, from his death in 322 B.C. until Galileo's destruction of his mechanics in 1609. Unfortunately, with the rise of modern physics over the past three centuries, Aristotle's achievements have been eclipsed. We honour the thinkers of antiquity who guessed right — the atomic theory of Democritus, the heliocentric view of Aristarchus — but not the man who we can truly say invented science. For his physics and astronomy, Aristotle has become identified as the barrier to scientific progress in the renaissance.

After he died, Aristotle's books, which represent perhaps just one-third of his total output, are said to have been buried in a cave in Asia Minor for 200 years. Although the Peripatetic philosopher Andronicus did prepare an edition of Aristotle's works in Rome shortly after their rediscovery, they were entirely lost to Europe following the fall of the Roman empire. It was not until the 11th and 12th centuries — thanks to Arabic translations from the Islamic kingdoms of Sicily and Spain — that his writings were rediscovered in Europe.

The image of Aristotle we have today is profoundly affected by Galileo's attack on his physics and on his world view. We are left with the idea that Aristotle represents all the worst aspects of medieval philosophy. Plato, on the other hand, is still cited

with approval by theorists and mathematicians, who love to imagine that their ideas represent some underlying reality about the universe.

A fairly characteristic view of Aristotle is given by the physicist J.D. Bernal in his book *Science in History* (1969 Penguin). "Bruno had to be burnt and Galileo condemned before doctrines which were derived from Aristotle... could be overthrown," he wrote. "The subsequent history of science is largely, in fact, the story of how Aristotle was overthrown in one field after another. Indeed Ramus was not far from the mark when he maintained in his famous thesis of 1536 'that everything Aristotle taught is false'."

Of course, Aristotle's incorrect picture of the Earth as the centre of the solar system had to be overthrown, as did several aspects of his dynamics, in order for the new physics of Galileo and Newton to emerge. But we are left with a diminished and usually inaccurate view of Aristotle's views and work. After all, many of Aristotle's insights and hypotheses were not superseded until well into the 19th century. His concept of a uniform, ever-flowing time was adopted unaltered by Newton and still has its place in relativistic physics in an inertial frame. We can surely not fail to take seriously someone whose scientific ideas are still alive after more than 2000 years. Some insight into Aristotle's scientific views can be obtained from his two great works on physics — *Physics* and *On the Heavens*. Aristotle had no mathematical machinery for dealing with the concept of acceleration, so he analysed only states of uniform velocity. He did not analyse frictionless uniform motion because such motion is not seen in the world. It was not until Newton that this Platonic concept of uniform motion in a straight line under no force was seen to be fundamental to dynamics.

The first state that Aristotle did analyse was motion under a constant force resisted by friction — such as a body of mass m being pulled or pushed along the ground. The corresponding Newtonian equation of motion is $m dv/dt = F - \mu mg$, where dv/dt is the acceleration, μ is the coefficient of friction, and g is the acceleration due to gravity. For uniform motion we then require, as stated by Aristotle, that a constant force (equal to μmg) must be exerted to overcome friction.

The second state analysed by Aristotle is uniform motion through a resistive medium like air or water — such as a body in free fall through a viscous medium. This was first correctly analysed by Stokes in the 19th century, who recog-

nized that the resistive force is proportional to the velocity. For a slowly falling sphere of radius r then (neglecting buoyancy) $mdv/dt = mg - 6 \pi r n v$, where n is the coefficient of viscosity. Thus the terminal velocity achieved by the falling body is $v = mg/6 \pi n r$.

Aristotle, however, stated that the terminal velocity is inversely proportional to the cross-sectional area, rather than the radius. In place of the coefficient of viscosity, he talked of the “thickness” of the medium. “The medium causes a difference [in the motion],” he wrote, “because it impedes the moving body, most markedly if it is moving in the opposite direction, but to a lesser degree even if it is at rest; and this is particularly true of a medium that is not easily cut through, i.e. a medium that is on the thick side. A body will move through a given medium in a given time, and through the same distance in a thinner medium in a shorter time, in proportion to the thicknesses of the hindering media.”

In other words, Aristotle came close to a correct statement of Stoke’s formula for the terminal velocity in a resistive medium. His analysis of the real, frictional and viscous world is therefore superior in some respects to that of Newton. Newton’s great advance was to deal with accelerated motions. Aristotle was aware that accelerations took place, but he was not able to incorporate them quantitatively.

In retrospect, the Achilles’ heel of Aristotle’s theory was his treatment of bodies moving against slight resistance. The problem is that the Stokes-Aristotle terminal velocity becomes very large as the viscosity tends to zero (as in air) and becomes infinite in the limit of a vacuum. Aristotle responded by saying a vacuum was impossible, but this still did not obviate the need to consider accelerations properly for motion of a projectile in air.

Another fundamental insight of Aristotle’s that was not correctly formulated in the Newtonian programme was the concept of power. Aristotle correctly defined the power of a machine lifting a body as being the weight multiplied by the distance moved, divided by time — in other words the rate of doing mechanical work. He also, very practically, pointed out that there is a threshold to get something moving when there is resistance by friction — “One man cannot move a ship,” as he put it.

(from *Physics World*, January 2002)

Note: i.e. — *id est*, that is (to say) — то есть

Mind the pronunciation of these words.

Lyceum [laɪˈsi:əm]
Democritus [diˈmɒkrɪtəs]
Aristarchus [ˌærɪˈstɑ:kəs]
Asia Minor [ˌeɪzəˈmaɪnə]
Islamic [ɪzˈlæmɪk]
Sicily [ˈsɪsəli]

projectile [prəʊˈdʒæktəl],
[ˈprɒdʒæktəl]
buoyancy [ˈbɔɪənsɪ]
quantitatively [ˈkwɒntɪtətɪvli]
Achilles [əˈkɪli:z]

Discussion points

1. Is it right to consider Aristotle as a barrier to scientific progress? Give your reasons.
2. What, in your opinion, is the most important contribution made by Aristotle?

Physics problems for fun

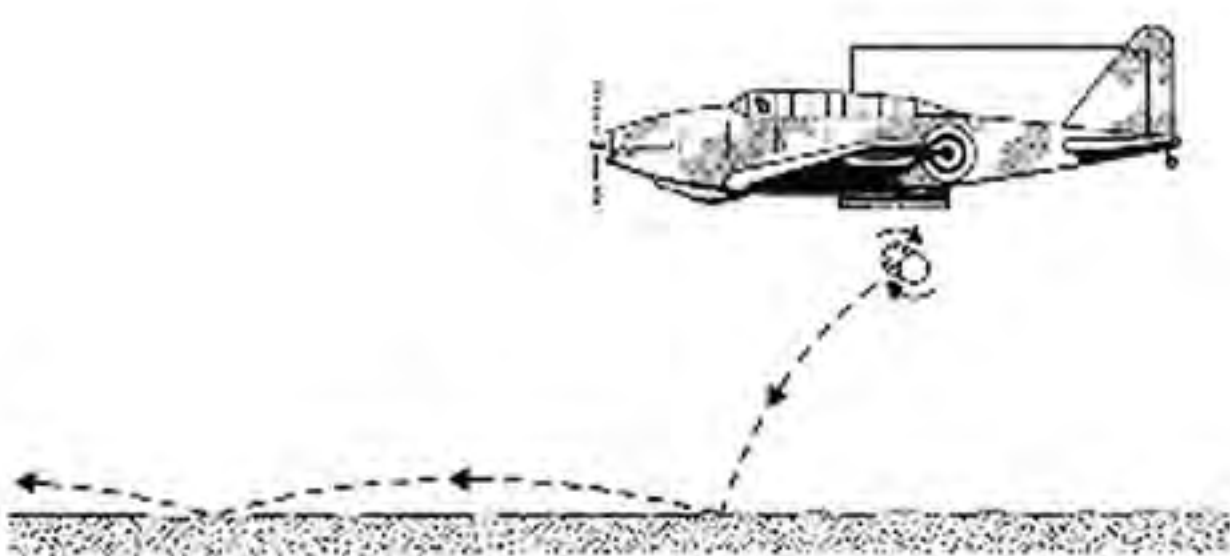
Think about possible answers to the problems below.

1. Skipping rocks

How does a stone skip across the water? If you skip a stone across hard-packed, wet sand, the marks in the sand provide a record of the stone's flight. You'll find the first bounce is short (several inches), the next is long (several feet), and this sequence repeats itself over and over until the stone



comes to rest. Why does it follow this pattern? During World War II the skipping rock effect was used by the British in the bombing of German dams. It is very difficult to drop a bomb on a dam, especially when you are being fired upon. So, the RAF developed a bomb (cylindrical, with a length of about 5 feet and a slightly smaller diameter) which was given a backspin around its length of about 500 rpm in the plane's bomb bay before it was released over the target. When it hit the water, the bomb skimmed like a stone, bouncing in shorter and shorter jumps until it hit the dam itself. Then, instead of rebounding away, the



back-spin forced it against the wall and made it crawl downwards until it exploded, on a hydrostatic fuse set for 30 feet below surface, still clinging to the dam. It was a beautifully simple idea for positioning a bomb weighing almost 10,000 lbs to within a few feet.

2. Archimedes's death ray

During the Roman attack of Syracuse about 214 B.C., the Greek scientist Archimedes supposedly saved his town by burning the Roman fleet with sunlight directed by mirrors located on the shore. Presumably, many soldiers simultaneously reflected the sun's image onto each ship in turn, and each ship was set on fire.

Considering that Archimedes did not have very large mirrors, would such a feat be possible? Can you estimate how many mirrors, let's say, one meter square, would be needed to set aflame dark wood 100 meters away within less than a minute? Should those mirrors be curved or flat if the target distance is variable? If they are flat, how large is the image of the sun on the wood? Finally, could Archimedes have destroyed the Roman Fleet in this manner?

(from *The Flying Circus of Physics* by J. Walker)

Unit IV

MAJOR DISCOVERIES AND ACHIEVEMENTS IN PHYSICS AND ENGINEERING. TOP PHYSICISTS OF ALL TIME

Grammar	Sequence of Tenses. Reported Speech. Indirect Questions. Oblique Moods. Conditional Sentences. Participle
Skills	Reading and Speaking. Paraphrasing. Critical Thinking

Reading I

Pre-text exercises

1. Check your pronunciation of the following words.

Einstein [ˈaɪnstain]	spontaneity [ˌspɒntəˈneɪəti]
subsequent [ˈsʌbsɪkwənt]	intrinsic [ɪnˈtrɪnsɪk]
total [təʊtl]	emphasize [ˈemfəsaɪz]
crowning [ˈkraʊnɪŋ]	unification [ˌjuːnɪfɪˈkeɪʃn]
intuitive [ɪnˈtjuːətɪv]	molecular [məˈlekjulə]
wonder [ˈwʌndə]	encapsulate [ɪnˈkæpsjuleɪt]
immutable [ɪˈmjʊ:təbl]	quantum [ˈkwɒntəm]
malleable [ˈmæliəbl]	inadequacy [ɪnˈædɪkwəsi]
satellite [ˈsætələɪt]	CERN [sɜːn]
causality [kɔːˈzæləti]	zinc [zɪŋk]

2. Practise reading the following word combinations.

subsequent theories, crowning achievement, major attempts, heavenly bodies, intuitive understanding, immutable space and time, satellite-based global positioning systems, a form of spontaneity, microelectronics industry, inconsistency of electromagnetism, inadequacy of classical physics, a unique way of ranking, worldwide recognition

Skimming

In 1999, *Physics World* decided to conduct a survey of physicists for the special millennium issue. They faxed and e-mailed a list of seven questions to over 250 physicists around the world. One of the questions was: *What have been the three most important discoveries in physics?* The findings of the survey seem to be most interesting.

3. Now read the text and say whether you agree with how the discoveries were characterised and ranked.

Time and again three key discoveries were singled out: quantum mechanics, Einstein's special and general theories of relativity, and Newtonian mechanics and gravitation. "In each of these three cases, the discovery in question not only revolutionized the branch of physics that it nominally addressed, but also provided a framework so deep and universal that all subsequent theories in physics have been formulated within it," said quantum-computation pioneer David Deutsch of Oxford University.

String theorist Michio Kaku of the City University of New York was even more clear-cut: "The sum total of our physical knowledge of the universe is contained in two theories: relativity and quantum theory. This is the crowning achievement of 2000 years of investigation into the universe, since the time of the Greeks."

Newton's laws of motion and gravity were selected because together they represented the first major attempts to create laws of physics that can be expressed in mathematical terms and tested by experiment. They also overturned the long-held belief that heavenly bodies obey different principles to those on Earth. "Newton set the pattern for all of us to follow," said Bernard Schutz from the Max Planck Institute for Gravitational Physics in Potsdam, Germany.

Einstein's theories of relativity, on the other hand, showed that our intuitive understanding of physical quantities can be challenged at every level. "Part of the wonder of science is its ability to peel away layers of common intuition to reveal the true nature of our universe — to reveal features that are remarkable, stunning and sometimes rather distant from our day-to-day experiences," enthused string theorist Brian Greene from Columbia University. "The special and general theories of relativity completely overturned previous conceptions of a universal, immutable space and time, and replaced them with a startling new framework in which space and time are fluid and malleable."

Einstein's theories also have practical applications: for example satellite-based global positioning systems, which are widely used for navigation on the Earth, have to take general relativistic effects into account.

The other hugely popular choice, quantum mechanics, was dubbed "the most radically revisionist physical discovery of all time" by the physicist and Anglican priest John Polkinghorne. Or, as astrophysicist Piet Hut of the Institute for Advanced Study in Princeton explained: "Quantum mechanics completely overturned the classical notions of causality, objectivity and repeatability of experiments, introducing instead a form of spontaneity intrinsic to the natural world." Many respondents also emphasized that quantum mechanics is not only elegant and powerful, but outstandingly useful as well. After all, quantum theory led to the development of semiconductors, transistors, lasers and — some might say — the entire microelectronics industry. It is also central to the design of new drugs and materials.

Maxwell's unification of electricity and magnetism was another popular choice, because it was the inconsistency of electromagnetism with Newtonian physics that led to the development of special relativity. Electromagnetism also gave birth to the idea of fields, which have had "a huge impact, both from a practical and conceptual point of view" according to Daan Frenkel of the FOM Institute for Atomic and Molecular Physics in Amsterdam.

The realization that all matter is made of atoms was also mentioned many times. "I agree with Richard Feynman," said Colin Humphreys, head of materials at Cambridge University, "when he said that if we could pass on just one sentence encapsulating the most important scientific knowledge we have, that sentence would be: 'All things are made of atoms'."

Many respondents, however, chose individual moments of discovery that paved the way for new revolutions in physics. David Awschalom from the University of California at Santa Barbara, for example, selected Planck's discovery of the quantum nature of light: "It was the first recognition of the fundamental inadequacy of classical physics. That was the hard part of quantum theory."

Meanwhile, Lydia Iconomidou-Fayard of the Linear Accelerator Laboratory in Orsay, near Paris, chose the discovery of radioactivity: "It was the starting point for nuclear and high-energy research, and completely modified the view that people had of matter."

Others chose the expansion of the universe, which led to the birth of modern cosmology, the invariance of the speed of light, which paved the way for relativity, and Thomson's discovery of the electron — "the first fundamental particle and, unlike many fundamental particles discovered thereafter, incredibly useful" according to Humphreys.

Rutherford's discovery of the atomic nucleus was also selected several times, as was the discovery by Francis Crick, James Watson, Maurice Wilkens and others of the structure of DNA. One of the discoveries to receive a mention was the evidence for neutrino mass, which was selected by astrophysicist Andrea Ghez of the University of California at Los Angeles.

Word list

address (<i>v</i>) — рассматривать, посвящать	causality (<i>n</i>) — причинная связь
framework (<i>n</i>) — рамки, пределы	intrinsic (<i>adj</i>) — присущий, свой- ственный
subsequent (<i>adj</i>) — последующий	elegant (<i>adj</i>) — интересный; ори- гинальный; плодотворный
clear-cut (<i>adj</i>) — ясный	powerful (<i>adj</i>) — эффективный; сильный; веский; могуществен- ный; мощный
crowning (<i>adj</i>) — блистательный	outstandingly (<i>adv</i>) — необычно, чрезвычайно
pattern (<i>n</i>) — образец	popular (<i>adj</i>) — всеобщий; рас- пространенный
quantity (<i>n</i>) — величина	inconsistency (<i>n</i>) — несоответ- ствие; противоречивость
peel (<i>v</i>) — снимать	encapsulate (<i>v</i>) — заключать в себе
stunning (<i>adj</i>) — потрясающий, изумительный	inadequacy (<i>n</i>) — неполноцен- ность; несовершенство
enthuse (<i>v</i>) — восхищаться, восторгаться	modify (<i>v</i>) — изменять
immutable (<i>adj</i>) — неизменный, непременный	expansion (<i>n</i>) — расширение
startling (<i>adj</i>) — поразительный	incredibly (<i>adv</i>) — потрясающе; чрезвычайно
fluid (<i>adj</i>) — жидкий, текучий; изменяющийся	
malleable (<i>adj</i>) — ковкий, тягучий	
satellite-based global positioning systems — спутниковые системы глобального позиционирования	

Scanning

4. Look through the text to find the following information:

- practical applications of Einstein's relativity theories;
- the role of Newtonian mechanics and gravitation;
- practical applications of quantum theory;
- consequences of the discovery of radioactivity.

Reading for Detail

5. Read the text again to find out whether the statements below are true or false.

The following opening phrases may be helpful.

I'm afraid that's wrong.
That's absolutely right.
Quite on the contrary.
That's not quite true.

I can't but agree.
As far as I remember...
Exactly so.
According to the text...

1. According to David Deutsch quantum mechanics, Einstein's relativity theories and Newtonian mechanics and gravitation were crucial to the development of all subsequent theories in physics.
2. It was Newton's laws of motion that overturned the long-held belief that planets and Earth obey different principles.
3. The special and general theories of relativity challenged previous conceptions of a universal, immutable space and time.
4. Practical applications of quantum mechanics are hardly worth mentioning.
5. Plank's discovery of the quantum nature of light revealed limitations of classical physics.
6. The discovery of radioactivity promoted nuclear and high energy research.

6. Paraphrase the following sentences and condense them omitting unnecessary details.

1. The discovery in question not only revolutionized the branch of physics that it nominally addressed, but also provided a framework so deep and universal that all subsequent theories in physics have been formulated within it.

2. Part of the wonder of science is its ability to peel away layers of common intuition to reveal the true nature of our universe — to reveal features that are remarkable, stunning and sometimes rather distant from our day-to-day experiences.

3. The special and general theories of relativity completely overturned previous conceptions of a universal, immutable space and time, and replaced them with a startling new framework in which space and time are fluid and malleable.

7. Reread the text and make a list of all the discoveries that were singled out in order of decreasing importance. Comment on the list and make your choice of the most important discoveries in physics. Give your reasons.

8. Find additional information on the discovery which, in your opinion, is the most important and give a 5-minute talk on it.

Vocabulary Work

1. Give the Russian equivalents for the following English word combinations.

key discoveries, the discovery in question, to provide a framework, subsequent theories, the crowning achievement, since the time of the Greeks, the major attempt, the long-held belief, to set the pattern to follow, at every level, to reveal the true nature of the universe, day-to-day experiences, satellite-based global positioning systems, a hugely popular choice, central to the design of new drugs and materials, the inconsistency of electromagnetism with Newtonian physics, both from a practical and conceptual point of view, to pave the way for new revolutions in physics, the fundamental inadequacy of classical physics, to lead to the birth of modern cosmology, to receive a mention

2. Find in the text the English equivalents for the following Russian word combinations.

квантовая механика, специальная и общая теории относительности Эйнштейна, механика и теория гравитации Ньютона, область физики, общая сумма физических знаний о вселенной, законы движения Ньютона и гравитация, создавать законы физики, проверяться экспериментом, небесные тела, интуитивное понимание физических величин, чудо науки, иметь практические применения, привести к созданию полупроводников (транзисторов, лазеров), объединение электричества и магнетизма, дать начало идее полей, оказать огромное воздействие, отправная точка, изменить взгляд (представление), инвариантность скорости света, чрезвычайно полезный, открытие атомного ядра, структура ДНК, свидетельство о наличии массы у нейтрино

3. Word building

- a) Form nouns of the verbs using the following suffixes: *-y*, *-ation*, *-ment*, *-(t)ion*, *-ality*, *-ent*, *-ication*.

discover, achieve, compute, navigate, investigate, cause, respond, develop, realize, recognize, unify, expand, accelerate

Think of other examples to illustrate this word building pattern.

- b) **Form adverbs of the following adjectives. Give their translation.**

nominal, complete, huge, radical, outstanding, incredible
--

Reading II

Pre-text exercises

1. **Check your pronunciation of the following words.**

endeavor [en'devə]
polymer ['pɒlɪmə]
fiber ['faɪbə]
composite ['kɒmpəzɪt]
ceramics [sə'remɪks]
supply [sə'plaɪ]
automobile ['ɔ:təmə(u)bɪ:l]
commitment [kə'mɪtmənt]
pursuit [pə'sju:t]

enterprise ['entəpraɪz]
processing ['prəusesɪŋ]
immediacy [ɪ'mɪ:diəsi]
abundant [ə'bʌndənt]
typhoid ['taɪfɔɪd]
fever ['fi:və]
cholera ['kɒlərə]
antibiotics [ˌæntɪbaɪ'ɒtɪks]
artificial [ˌɑ:trɪ'fiʃəl]

2. **Practise reading the following word combinations. Give their Russian equivalents.**

engineering breakthroughs, hospitable place, broad spectrum, human endeavor, vast networks, high-performance materials, steel alloys, synthetic fibers, health technologies, interstate highways, profound changes, incredible advancements, space exploration, commonplace technologies, staggering impact, stable environments, mode of transportation, expand horizons, unparalleled access

Pre-reading task

3. **Read the text about top 20 engineering achievements of the 20th century and answer the following questions.**

1) What does Neil Armstrong say about engineering breakthroughs selected by the National Academy of Engineering?

2) What other advancements have revolutionized the way people live, work and travel?

3) What is considered to be the top achievement and how did it impact our daily life?

4) What drastic changes in life expectancy did the availability of safe and abundant water introduce?

5) How does modern society profit by air conditioning and refrigeration technologies?

6) What engineering achievements, in your opinion, made space exploration possible?

Top 20 Engineering Achievements of the 20th Century

In the fall of 1999, the National Academy of Engineering (USA) invited 29 professional engineering societies to nominate up to ten achievements that have had the greatest impact on quality of life in the 20th century. The achievements were selected and ranked by a distinguished panel of the nation's top engineers. The announcement was made by astronaut / engineer Neil Armstrong who spoke on behalf of the National Academy of Engineering at a National Press Club meeting (2000).

"As we look at engineering breakthroughs selected by the National Academy of Engineering, we can see that if any one of them were removed, our world would be a very different — and much less hospitable place," said Armstrong. Armstrong's announcement of the top 20 list, which includes space exploration as the 12th most important achievement, covers an incredibly broad spectrum of human endeavor — from the vast networks of electrification in the world (No. 1), to the development of high-performance materials (No. 20) such as steel alloys, polymers, synthetic fibers, composites and ceramics. In between are advancements that have revolutionized the way people live (safe water supply and treatment, No. 4, and health technologies, No. 16); work (computers, No. 8, and telephones, No. 9); play (radio and television, No. 6); and travel (automobile, No. 2, airplane, No. 3, and interstate highways, No. 11).

In his statement delivered to the National Press Club, Armstrong said that he was delighted to announce the list of the greatest achievements to underscore his commitment to advancing the understanding of the critical importance of engineering. "Almost every part of our lives underwent profound changes during the past 100 years thanks to the efforts of engineers, changes impossible to imagine a century ago. People living in the early 1900s would be amazed at the advancements wrought by engineers," he said, adding, "as someone who has experienced first-hand one of engineering's most incredible advancements — space exploration — I have no doubt that the next 100 years will be even more amazing."

The NAE notes that the top achievement, electrification, powers almost every pursuit and enterprise in modern society.

It has literally lighted the world and impacted countless areas of daily life, including food production and processing, air conditioning and heating, refrigeration, entertainment, transportation, communication, health care, and computers.

Many of the top 20 achievements, given the immediacy of their impact on the public, seem obvious choices, such as automobiles, at No. 2, and the airplane, at No. 3. These achievements, along with space exploration, the nation's interstate highway system at No. 11, and petroleum and gas technologies at No. 17, made travel and mobility-related achievements the single largest segment of engineering to be recognized.

Other achievements are less obvious, but nonetheless introduced changes of staggering proportions. The No. 4 achievement, for example, the availability of safe and abundant water, literally changed the way Americans lived and died during the last century. In the early 1900s, waterborne diseases like typhoid fever and cholera killed tens-of-thousands of people annually, and dysentery and diarrhea, the most common waterborne diseases, were the third largest cause of death. By the 1940s, however, water treatment and distribution systems devised by engineers had almost totally eliminated these diseases in America and other developed nations. They also brought water to vast tracts of land that would otherwise have been uninhabitable.

Number 10, air conditioning and refrigeration technologies, underscores how seemingly commonplace technologies can have a staggering impact on the economy of cities and worker productivity. Air conditioning and refrigeration allowed people to live and work effectively in sweltering climates, had a profound impact on the distribution and preservation of our food supply, and provided stable environments for the sensitive components that underlie today's information-technology economy.

Referring to achievements that may escape notice by most of the general public, W.A. Wulf, president of the National Academy of Engineering, said, "Engineering is all around us, so people often take it for granted, like air and water. Ask yourself, what do I touch that is not engineered? Engineering develops and delivers consumer goods, builds the networks of highways, air and rail travel, and the Internet, mass produces antibiotics, creates artificial heart valves, builds lasers, and offers such wonders as imaging technology and conveniences like microwave ovens and compact discs. In short, engineers make our quality of life possible."

Here is the complete list of achievements as announced by Mr. Armstrong:

1. **Electrification** — the vast networks of electricity that power the developed world.
2. **Automobile** — revolutionary manufacturing practices made the automobile the world's major mode of transportation by making cars more reliable and affordable to the masses.
3. **Airplane** — flying made the world accessible, spurring globalization on a grand scale.
4. **Safe and Abundant Water** — preventing the spread of disease, increasing life expectancy.
5. **Electronics** — vacuum tubes and, later, transistors that underlie nearly all modern life.
6. **Radio and Television** — dramatically changed the way the world received information and entertainment.
7. **Agricultural Mechanization** — leading to a vastly larger, safer, less costly food supply.
8. **Computers** — the heart of the numerous operations and systems that impact our lives.
9. **Telephone** — changing the way the world communicates personally and in business.
10. **Air Conditioning and Refrigeration** — beyond convenience, it extends the shelf life of food and medicines, protects electronics, and plays an important role in health care delivery.
11. **Interstate Highways** — 44,000 miles of U.S. highway allowing goods distribution and personal access.
12. **Space Exploration** — going to outer space vastly expanded humanity's horizons and introduced 60,000 new products on Earth.
13. **Internet** — a global communications and information system of unparalleled access.
14. **Imaging Technologies** — revolutionized medical diagnostics.
15. **Household Appliances** — eliminated strenuous, laborious tasks, especially for women.
16. **Health Technologies** — mass production of antibiotics and artificial implants led to vast health improvements.
17. **Petroleum and Gas Technologies** — the fuels that energized the 20th century.
18. **Laser and Fiber Optics** — applications are wide and varied, including almost simultaneous worldwide communications, non-invasive surgery, and point-of-sale scanners.

19. **Nuclear Technologies** — from splitting the atom, we gained a new source of electric power.
20. **High Performance Materials** — higher quality, lighter, stronger, and more adaptable.
(<http://composite.about.com/od/inthenews/1/blnae1.htm>)
4. **Reread the text and comment on the choice of the most important achievements of the 20th century.**
5. **Make up your own list of at least 10 engineering breakthroughs. Give your reasons.**
6. **Choose one of the achievements to speak about in more detail. You can find additional information at <http://www.nationalacademies.org/greatachievements/List.PDF>**
7. **Study the list of “Grand Challenges” facing the global society in the 21st century.**

- | | |
|---|--|
| 1. Make solar energy economical | 8. Engineer better medicines |
| 2. Provide energy from fusion | 9. Reverse-engineer the brain |
| 3. Develop carbon sequestration methods | 10. Prevent nuclear terror |
| 4. Manage the nitrogen cycle | 11. Secure cyberspace |
| 5. Provide access to clean water | 12. Enhance virtual reality |
| 6. Restore and improve urban infrastructure | 13. Advance personalized learning |
| 7. Advance health informatics | 14. Engineer the tools of scientific discovery |

(http://www.lit.edu/grand_challenges/about/)

8. **Choose some of the areas related to the challenges above to speak about in greater depth.**

Development

1. **Look through the text and find the answers to the following questions.**
 1. What are the two revolutions in physics and how long did they last?
 2. What scientists contributed to the revolutionary development of physics during the first period of rapid change?
 3. What is the outcome of the first revolution?
 4. What role did Einstein play in the conceptual breakthroughs in physics?
 5. What makes it difficult to understand relativity and quantum mechanics?

Physics has two periods of rapid change. (The word "revolution" has been much abused of late, but it is probably appropriate.) The first revolution occupied most of the 17th century and was so complete that almost nothing preceding it can be recognized as physics at all, in modern terms. The second occupied the first three decades of the 20th century, and it is not clear that we have seen the end of it.

It is convenient to regard the first revolution as beginning with Galileo and culminating with Newton. It created classical mechanics, probably the most successful scientific theory of all time. For two centuries, this theory swept all before it, one phenomenon after another yielding to explanation in mechanical terms. At the end of the 19th century, it seemed on the verge of absorbing optics and electromagnetism of that time, it appeared already to have done so, except for a few minor details. But on these last details it ultimately failed — and failed catastrophically.

The second revolution has, in fact, compounded the confusion by striking out in two new directions: relativity and quantum mechanics. The former was largely the creation of one man, Albert Einstein. The latter grew from the contributions of many thinkers (including Einstein). Relativity is popularly regarded as bizarre and abstruse, but the quantum theory is far more so. Both theories were conceived, at least in part, in much the same spirit — that of critical evaluation of the process by which a physicist actually observes the world in which he lives. Both deal mainly with phenomena that lie outside the realm of ordinary experience. It is partly for this reason that they are so difficult to teach — the phenomena themselves are beyond our day-to-day experience. Both theories contain startling concepts that seem absurd or paradoxical, for they conflict with basic intuitive feelings about space and time, cause and effect.

(from *Physics for Poets* by R.H. March)

2. Read the text again and entitle it.
3. Write a summary of the text in 8–10 sentences.
4. a) Read the following text which contains some biographical facts from the life of an outstanding scientist Sir Isaac Newton. What fact(s) do you find most impressive?

Check whether you pronounce these words correctly.

crucial ['kruʃ(ə)l]
 binomial [baɪ'nəʊmɪəl]
 reluctance [rɪ'lʌktəns]
 circumvent [ˌsɜ:kəm'vent]
 inherent [ɪn'hɪərənt]
 encourage [ɪn'kʌrɪdʒ]
 dispute [dɪ'spju:t; 'dɪspju:t]

withdraw [wɪð'drɔ:]
 urge [ɜ:dʒ]
 constitute ['kɒnstɪtju:t]
 theology [θi'ɒlədʒɪ]
 priority [praɪ'ɒrəti]
 assume [ə'sju:m]
 knight [naɪt]

Sir Isaac Newton (1642–1727)

Born in 1642, the year of Galileo's death, Newton made the crucial advances needed to complete our understanding of motion. He also made major contributions to optics and mathematics. As an undergraduate at Cambridge (1661–1665), Newton soon mastered the literature of science and mathematics and began to enter unexplored regions. He formulated the binomial theorem and the basic concepts of calculus. During this period and the years immediately following, he also began to do research on optics and on planetary motion. He deduced that the force on a planet due to the sun must vary as $1/r^2$. Some 20 years later, he would extend this idea to the universal law of gravitation. Although Newton's work was known only to a limited circle because of his reluctance to publish his research, he was appointed a professor at Cambridge in 1669. He developed the first reflecting telescope in order to circumvent the distortion inherent in lenses. When this telescope received an enthusiastic reception from the Royal Society of London, he was encouraged to present his other research in optics to the Society in 1672. Robert Hooke, the leading authority on optics, disagreed with some Newton's ideas. This led to bitter disputes, with Newton finally withdrawing into isolation for some years. Newton's greatest achievements were his advances in mechanics. Although many of his results were obtained quite early in his career, he did not present his theory of planetary motion until he was urged to do so in 1684 by Edmond Halley, an astronomer who had heard of Newton's work. Newton's classic work, *Principia Mathematica*, appeared in 1687. Written in Latin, it contained the three laws of motion and the universal law of gravitation. This treatise constituted one of the foundations of modern science and

made Newton internationally famous. It also effectively marked the end of Newton's active research, with his attention gradually turning to politics, theology, and scientific priority disputes. Newton became master of the mint, a well-paying and normally undemanding job. He also assumed the role of the leader of English science, becoming president of the Royal Society in 1703; in 1705, he became the first scientist to be knighted. Unfortunately, he repeatedly used his position to carry on bitter arguments with various scientists. The most prolonged of these was a 25-year battle with Leibniz (which ended with Newton's death in 1727) over credit for the development of the calculus. It is now agreed that Leibniz independently developed the calculus after Newton had, but before Newton published his results.

(from *General Physics*)

Word list

undergraduate (*n*) — студент
 calculus (*n*) — исчисление
 circumvent (*v*) — обходить
 reluctance (*n*) — нежелание
 distortion (*n*) — искажение
 inherent (*adj*) — присущий, свойственный
 withdraw (*v*) — уходить
 urge (*v*) — убеждать
 mint (*n*) — монетный двор

assume (*v*) — принимать; предполагать
 knight (*v*) — возводить в рыцарское достоинство
 repeatedly (*adv*) — неоднократно
 carry on (*v*) — вести; продолжать
 bitter (*adj*) — горький; ожесточенный; острый
 credit (*n*) — честь; вера

b) Divide the text into six paragraphs according to the following headings:

- introduction
- early scientific career (as an undergraduate and the years immediately following)
- research in optics
- achievements in mechanics
- the end of active research
- the leader of English science

c) Write questions about Sir Isaac Newton and let other students answer them.

d) Speak about Newton's contributions to science.

5. Translate the text about the influence of Newton's laws of motion on science at sight. Guess the meaning of the unknown words from the context.

Although there are many kinds of forces in nature, the effects of any force are described accurately by three general laws of mo-

tion first stated fully by Sir Isaac Newton. Guided by earlier astronomical observations and making several giant steps of intuition, Newton developed the laws of motion and also the expression for the gravitational attraction between two objects. He then showed that the orbital motions of the planets and moon were in quantitative agreement with the predictions he made using these laws.

Newton's work represented a tremendous step forward in our understanding of the natural world and exerted a great influence on science and on the way people viewed science. For over two centuries, Newton's laws of motion served as the foundation of mechanics, with later workers finding full agreement between theory and experiment for a wide range of phenomena. Even though twentieth-century advances have shown that Newton's laws are inadequate at the atomic scale and at velocities comparable to the speed of light, $3 \times 10^8 \text{ m} \cdot \text{s}^{-1}$, they provide an extremely accurate framework for discussing the motions of macroscopic objects at ordinary velocity. Thus, they are fully adequate for most applications in fields such as astronomy, biomechanics, geology and engineering.

(from *General Physics*)

6. **Combine the following sentences to form a coherent text. You may change the order of information if necessary.**

Mind the pronunciation of the following words.

Ulm [ulm]

Munich ['mjʊ:nɪk]

Zurich ['zuərɪk]

patent ['pɛtnt; 'pætnɪ]

isolation [ˌaɪsəˈleɪʃn]

duplication [ˌdju:plɪˈkeɪʃn]

Berlin [bɜ:ˈlɪn]

Nazis ['na:tsɪz; 'na:zɪz]

Albert Einstein was born in Ulm in 1879.

Ulm is a small town near Munich in Germany.

His father was a businessman.

He began his schooling in Munich.

Later, the family moved to Italy.

He continued his education in Switzerland.

In 1896, he entered the Swiss Federal Polytechnic School in Zurich.

He was trained as a teacher in physics and mathematics.

In 1901, he gained his diploma.

He acquired Swiss citizenship in 1901.

He was unable to find a teaching post.

He accepted a position as technical assistant in the Swiss Patent Office in Bern.

The Patent Office was quiet.

He had enough time to do research in theoretical physics.

He did research in isolation from others working on contemporary problems.

Some of his work was a duplication of that already done.

By 1905, he was working on unsolved problems.

He was making immense success in developing new ideas and concepts.

In 1905, he obtained his doctor's degree.

By the end of 1905, he had developed the special theory of relativity.

He explained the photoelectric effect.

He was well on his way to formulating the general theory of relativity.

By 1913, his scientific work had brought great professional praise.

In 1914, he was appointed Director of the Kaiser Wilhelm Physical Institute.

He became Professor in the University of Berlin in the same year.

The general theory of relativity was published in 1916.

He was awarded the Nobel prize for theoretical physics research in 1921.

The Nazis gained power in Germany.

He emigrated to the United States in 1933.

He took the position of Professor of Theoretical Physics at Princeton.

He never returned to his home land.

He died in 1955.

His name is still used as a synonym for the revolutionary development of modern natural sciences.

You may use connectives from the box.

Because	As
Since	Consequently
However	Although
While	In fact

7. Translate the following extract from Einstein's biography in writing.

Судя по всему, Эйнштейн обладал ясным взглядом на проблемы физики и намерением (determination) их решать. У него была своя собственная стратегия, он обладал способностью визуализировать (visualize) основные этапы

на пути к своей цели. Свои огромные достижения он считал не более чем подготовительными этапами (stepping-stones) на пути к следующему успеху.

В начале научной работы Эйнштейн осознал неадекватность некоторых аспектов механики Ньютона, и из его попытки примирить (reconcile) законы механики с законами электромагнитного поля родилась (stem from) специальная теория относительности. Он работал (deal with) с классическими проблемами статистической механики (statistical mechanics), а также с проблемами, где эти задачи сливались (merge) с квантовой теорией: это привело к объяснению броуновского движения (Brownian movement) молекул. Он исследовал тепловые (thermal) свойства света с низкой плотностью излучения (radiation density), и его наблюдения заложили основы (lay the foundation) фотонной теории света.

В начале своей карьеры, еще в Берлине, Эйнштейн постулировал, что правильная интерпретация специальной теории относительности также должна давать (furnish) и теорию гравитации, а в 1916 году опубликовал статью по общей теории относительности. За это время он также сделал немалый вклад в решение проблем излучения (theory of radiation) и статистической механики.

В 1920-е годы Эйнштейн начал построение (construction) единой теории поля (unified field theory), хотя не прекращал работать и над вероятностной (probabilistic) интерпретацией квантовой теории. Он сделал большой вклад в статистическую механику, разработав квантовую теорию одноатомного газа (monatomic gas), а также выполнил (accomplish) ценную работу, связанную с (in connection with) вероятностями атомных переходов (atomic transition probabilities) и релятивистской космологией.

(«Нобелевские лекции по физике. 1901–1921»,
под ред. С. Г. Новокшопова, 2002)

8. Find additional information about Einstein and share it with other students.

Active Vocabulary

account	evidence	knowledge
agree	feature	provide
apply	follow	realize
concern	investigate	view

1. account for [ə'kaunt] (*v*) объяснять; составлять отчет, отчитываться; составлять

help smb to ~ for

помочь кому-л. объяснить что-л.

account (*n*) расчет, счет; представление; отчет; объяснение

an accurate / unbiased /
detailed / full ~

точный / непредвзятый / подроб-
ный / полный отчет

to develop / examine / give /
make / render an ~

разработать / изучить / дать /
сделать / предъявить отчет

to take into ~ / to take ~ of

учитывать

to leave / put out of ~

не принимать во внимание

on this ~

ввиду этого

on ~ of

вследствие, из-за

of no ~

незначительный

on no ~

ни в коем случае

2. agree [ə'gri:] (*v*) соглашаться; решать, договариваться; соответствовать, совпадать

to ~ closely / nicely / well with

хорошо согласовываться с

to ~ on a subject / issue /
point / principle

договориться о теме / вопросе /
пункте / принципе

to ~ with facts

соответствовать фактам

to ~ with a view

соглашаться с мнением

to ~ in essence

совпадать в основном

It is generally agreed that...

Общепризнанно, что...

We cannot but ~ that...

Мы не можем не согласиться,
что...

agreement [ə'gri:mənt] (*n*) договор; соглашение, согласие; соответствие

a close / complete, full ~

близкое / полное соответствие

a detailed ~ between theory and
observation

точное совпадение теоретических
и экспериментальных данных

by mutual ~

по взаимному согласию

to be in ~ with smth

соответствовать чему-л.

to come to an ~ on /
about smth

приходить к соглашению

to conclude an ~

по какому-л. вопросу
заключить соглашение (договор)

to make an ~ with smb about smth

договориться с кем-л. о чем-л.

to reach an ~

достигнуть договоренности
(соглашения)

disagreement (*n*) разногласие

3. apply [ə'plai] (*v*) применять, употреблять; обращаться; относиться, касаться, подходить

to ~ an approach / method / notion / criterion	применять подход / метод / понятие / критерий
to ~ theory to practice	применять теорию на практике
to ~ the rule / achievement	применять правило / достижение
to ~ corrections	вносить поправки
to ~ to a case	применяться к случаю
to ~ for a job	подавать заявление о приеме на работу
to ~ to the council for a grant	обращаться в Совет за грантом
to ~ voltage	прикладывать напряжение
The same applies to...	То же самое относится к...

applied (*adj*) прикладной, практический

~ sciences	прикладные науки
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applicable ['æplɪkəbl], [ə'plɪkəbl] (*adj*) применимый, пригодный, подходящий

a concept / idea / rule ~ to	понятие / идея / правило, при- меняемое к
~ to a case / process / task	применимый к случаю / про- цессу / задаче
~ to a less / greater degree to	применимый в меньшей / боль- шей степени к

applicability [ə,plɪkə'bɪlətɪ] (*n*) применимость

application [æplɪ'keɪʃn] (*n*) приложение; применение; употребле-
ние; случай; заявление, просьба; прикладная задача

proper / correct / practical ~	надлежащее / правильное / прак- тическое применение
for critical ~s	в важных случаях, в случаях крайней необходимости
in such an ~	в данном случае
the ~ of theory to practice	применение теории на практике
~ of new techniques and technolo- gies	применение новых методов и тех- нологий
on ~	по заявке
~ form	заявление-анкета
~ program	прикладная программа

4. concern [kən'sɜ:n] (*v*) касаться, иметь дело, иметь отноше-
ние, интересоваться

to ~ a question	иметь отношение к вопросу
to ~ oneself with	иметь дело с, заниматься чем-л.
to be ~ed about smth	беспокоиться о чем-л.
as far as smth is ~ed	что касается
The article is concerned with...	В статье рассматривается...

concern (*n*) участие, интерес, внимание; значение, важность; цель, задача

a matter of a great ~
The main (primary) ~ of
the book is...
It is no ~ of mine.

очень важное дело
Основная (первоочередная)
задача книги состоит в...
Это меня не касается.

concerned (*adj*) заинтересованный; рассматриваемый; связанный

all ~
the parties ~

все заинтересованные лица
заинтересованные стороны

concerning (*prep*) относительно

5. evidence ['evidəns] (*n*) доказательство, свидетельство, признак(и); данные, факт(ы); основание

conclusive, convincing / current /
(in)direct / reliable /
significant / strong ~

убедительные / существующие /
(косвенные) прямые / надеж-
ные / важные / веские доказа-
тельства

to provide another piece of ~

давать (представлять) дополни-
тельные данные

to rest on ~
to give ~ (of)

основываться на данных (фактах)
свидетельствовать (о), подтверж-
дать

to show ~ of smth
to obtain / find / support ~

проявлять признаки чего-л.
получать / находить / подкреп-
лять данные

a body of ~
the chief kind of ~
all types of ~
the nature of ~
the current ~ about / available
from / regarding smth

основная часть данных
главное доказательство
все виды доказательств
характер данных
существующие доказательства
чего-л. / полученные из / каса-
ющиеся чего-л.

to find the ~ convincing

считать доказательстваубеди-
тельными

There is some ~ that...

Есть указания на то, что... / при-
знаки того, что...

There is no ~ for...
There is little ~ that...

Нет оснований для...
Мало оснований думать, что ...

evident ['evidənt] (*adj*) очевидный, ясный, явный

It is / becomes / seems ~
that...
From the preceding, it should be ~
why...

Очевидно / становится очевид-
ным / кажется очевидным, что...
Из предыдущего должно быть
ясно, почему...

evidently ['evid(ə)ntli] (*adv*) очевидно, явно, ясно

6. feature [ˈfi:tʃə] (*n*) деталь, элемент; черта, признак, свойство; характерная особенность; техническая характеристика; параметр

a basic / distinctive /
notable / novel / relevant/
significant / unique ~

основная / отличительная /
заметная / новая / соответствующая / важная / уникальная
особенность (черта)

~ s common to all
to exhibit / reveal
a number of ~s

свойства, общие для всех
проявлять / обнаруживать
ряд свойств

feature (*v*) быть характерной чертой, отличать; изображать, рисовать; широко освещать

7. follow [ˈfɒləʊ] (*v*) следовать; следить; понимать; применять, использовать

to ~ advice
to ~ from a principle
to ~ from a definition
to ~ smb's example
to ~ a rule

следовать совету
логически вытекать из принципа
следовать из определения
следовать чьему-л. примеру
следовать правилу / соблюдать
правило

to frame a question as ~s
to ~ the method
to be ~ed by
In decades that ~ed...
As ~s from...
It ~s from what has just been said
that...
It ~s from the above that...

обобщить следующим образом
придерживаться метода
сопровождаться чем-л.
В последующие десятилетия...
Как следует из...
Из только что сказанного следует,
что...
Из вышеупомянутого следует,
что...

In what ~s...
as ~s
The plan was as ~s.
I don't ~ you.

Ниже...
следующим образом
План был таков.
Я вас не понимаю.

following [ˈfɒləʊɪŋ] (*adj*) следующий

in the ~ way
to ask the ~ questions
to make the ~ points
The ~ table shows that...

следующим образом
задавать следующие вопросы
отмечать следующие аспекты
В следующей таблице показано,
что...

8. investigate [ɪnˈvestɪgeɪt] (*v*) исследовать, расследовать

to ~ a case / problem /
situation

исследовать случай / проблему /
ситуацию

investigation (*n*) исследование, расследование

a close / detailed /
further / important ~

an ~ in / into smth
on / upon (closer) ~

to be under ~
the problem under ~
to carry out / conduct /
make an ~
This ~ focuses on...

тщательное / подробное /
дальнейшее / важное исследо-
вание

исследование чего-л.
при (более тщательном) иссле-
довании

исследоваться
исследуемая проблема
проводить исследование

Это исследование направлено
на (связано с)...

9. **knowledge** [ˈnɒlɪdʒ] (*n*) знание; знания; представление; све- дения

accurate / adequate /
detailed / profound ~
to acquire / gain / obtain ~
the lack of ~

It is common ~ that...

To the best of my ~ ...

Our present ~ of...
stems from...

Most of our ~ is based on...

There are gaps in our ~ of...

точные / надлежащие /
точные / глубокие знания

получать знания
отсутствие знаний

Общеизвестно, что...

Насколько мне известно, ...

Наши современные знания о...
берут начало...

Большая часть наших знаний
основана на...

Есть пробелы в наших зна-
ниях о...

10. **provide** [prəˈvaɪd] (*v*) давать, снабжать; обеспечивать; предусматривать (*for*)

to ~ education

to ~ advice / information /
evidence / (further) impetus / clue
to / insight into /
explanation for

to ~ smb with knowledge /
information / criteria

давать образование

давать совет / информацию /
доказательство / (дальней-
ший) стимул / ключ к / пред-
ставление о / объяснение

обеспечивать кого-л. знаниями /
информацией / критериями

provided, -ing (that) (*conj*) при условии, что; в том случае, если
provision (*n*) обеспечение

11. **realize** [ˈrɪəlaɪz] (*v*) осознавать; понимать; реализовать, выполнять, осуществлять

to ~ the forthcoming difficulties

to ~ a project

It is important to ~ that...

осознавать предстоящие труд-
ности

осуществлять проект

Важно понимать, что...

realization [ˌrɪəlaɪˈzeɪʃn] (*n*) осознание; осуществление

to come to a ~

прийти к пониманию

~ of a plan

осуществление плана

12. view [vju:] (*v*) рассматривать; оценивать; осматривать

to ~ an object / phenomenon /
problem

рассматривать объект / явление /
проблему

view (*n*) вид, изображение; взгляд; мнение; кругозор

(an) advanced / contrary /
conventional / modern /
outspoken / prevalent /
realistic / sound ~

прогрессивный / противополож-
ный / обычный / современ-
ный / откровенный / преоб-
ладающий / реалистичный /
разумный взгляд

a ~ about / on a question /
problem / matter

мнение о вопросе /
проблеме / деле

the scientific ~ of the world

научное мировоззрение

to have a clear ~

иметь хорошую видимость

an overall ~ of the situation

общая картина положения

on a closer ~

при ближайшем рассмотрении

to have strong ~s on the subject

иметь насчет чего-л. твердые
убеждения

to accept / advance / challenge /
defend / express / put forward a ~

принимать / выдвигать / кри-
тиковать / защищать / выра-
жать / выдвигать точку зрения

to exchange ~s

обмениваться мнениями

according to a ~

согласно точке зрения / мнению

point of ~

точка зрения

in ~ of

ввиду, принимая во внимание,
в связи с

with a ~ to

с целью, с намерением

in my ~

на мой взгляд

I take a different ~.

У меня другая точка зрения.

viewpoint (*n*) точка зрения

from smb's ~

с чьей-л. точки зрения

to disagree with a ~

не соглашаться с точкой зрения

Vocabulary Work

1. Find the sentences in which the words from the Active Vocabulary are used in the text at the beginning of this Unit and translate them.

2. Consulting the Active Vocabulary

a) Translate the following word combinations from English into Russian and use some of them in the sentences of your own.

to take into account, on this account, an unbiased account,
to agree in essence, by mutual agreement, to conclude an agree-

ment, to reach an agreement, to apply a criterion, to apply corrections, applicable to a less degree, on application, to be concerned about smth, a matter of great concern, the parties concerned, to rest on evidence, current evidence, a body of evidence, to find the evidence convincing, a unique feature, features common to all, to follow from a principle, to frame a question as follows, in what follows, to make the following points, a close investigation, to be under investigation, profound knowledge, to the best of my knowledge, to provide impetus, to realize the forthcoming difficulties, to come to a realization, an outspoken view, to have a clear view, to have strong views on the subject, to take a different view, to challenge a view, with a view to

b) Give the English equivalents for the following words, word combinations and phrases.

сделать подробный отчет, не принимать во внимание, ни в коем случае, вследствие, соответствовать фактам, приходить к соглашению по какому-либо вопросу, применять подход, применяться к случаю, обращаться в Совет за грантом, прикладные науки, применение теории на практике, что касается, иметь отношение к вопросу, относительно, представить убедительные доказательства против чего-либо, характер данных, очевидно, заметная особенность, ряд свойств, следовать совету, в последующие десятилетия, следующим образом, задавать следующие вопросы, проводить исследование, исследуемая проблема, надлежащие знания, получать знания, отсутствие знаний, общеизвестно, что..., пробелы в знаниях, дать представление о чем-либо, обеспечить кого-либо информацией, при условии, что..., осуществлять проект, важно понимать, что ..., рассматривать явление, преобладающий взгляд, при ближайшем рассмотрении, выдвигать точку зрения, согласно мнению, принимая во внимание, не соглашаться с точкой зрения

3. Translate the sentences from English into Russian.

1. For the long-term experiments to be realizable various aspects of the problem must be taken into **account**. We no longer use this theory because it fails to **account for** the causes of this phenomenon. We take this historical **account** to represent the current state of affairs. This **account** is inappropriate to understand the cases mentioned above.

2. The results obtained with this technique are in good **agreement** with the data reported earlier by a number of authors. Despite a great deal of theoretical effort there is still no clear **agreement** on the physical significance of this phenome-

non. The results reveal close *agreement* between experimental and computed values. There is no *agreement* about the nature and status of such objects. The two invariants *agree* with those found previously.

3. To close this section we shall discuss the principal conclusions from the work and possible *applications* of the obtained results. This criterion better *applies* to exceptional than regular cases. After World War II, totally new tools *were applied* to the study of atomic structure. Some of the first scientific *applications* for laser light were devoted to the study of non-linear effects. The question remains whether this approach is *applicable* in all cases. This criterion does not *apply* to our case.

4. The papers given at the congress *were concerned* with theoretical and experimental problems of solid-state physics. *As far as* this discussion *is concerned* it proved to be very stimulating. The second important effect *concerns* the intermolecular forces when the molecules are close together. The algorithm details do not *concern* us here.

5. An explanation of phenomena such as the photoelectric effect presents very convincing *evidence* in support of the photon concept of light. The *evidence* for the existence of such particles was not fully convincing at the time. They have failed to find *evidence* for such changes. However, *evidence* to the contrary exists. Particle physics provides another important piece of *evidence*. Only one line of *evidence* bears on the question.

6. The morning session *will feature* reports on methodology unique to this area of physics. There is an additional *feature* that aggravates the problem. I also have to point out another specific *feature* of interstellar travel. The silicon surface contains interesting topographic *features* including steps, islands, and point defects. This apparatus *features* extraordinary stability.

7. I should like to thank the *following* for their helpful comments on this paper. The results will be discussed *in what follows*. I shall not *follow* through the consequences of the discovery in this article. The main principle may be summarized *as follows*. In the decade that *followed*, the research project became increasingly complex. These data came about in the *following* way.

8. No doubt, this complicated problem will be thoroughly *investigated*. The book gives a detailed account of the method of *investigation*. We hoped that these *investigations* would fill the gap in our understanding of the mechanism. One related possibility remains *to be investigated*.

9. The entire experience of mankind and scientific **knowledge** have made inevitable the conclusion that travel in time is impossible. **It is common knowledge** that the latest developments in this area of chemistry are of special interest. Not only must the researcher have a fundamental **knowledge** of his subject but he should also possess a creative mind.

10. These observations **provide** further impetus for the development of laser devices. The calculations **provide** an important insight into the microscopic mechanisms that influence superconductivity. Most modern accelerators do not **provide** a steady flow of particles, generally because that would require too much electric power. These transitions of electrons may occur **provided that** sufficient energy is available.

11. Einstein **realized** the scale of the threat brought by nuclear weapons to mankind, and thus advocated international control of nuclear arsenals. It is now **realized** that a real gas cannot be rigorously described by any simple equation of state. The **realization** of these difficulties did not stop them from further research. Among examples of **realizations** of the wildest dreams are the liberation of atomic energy, space flights and many others.

12. The astronomers did not directly **view** the second disk of this galaxy, but deduced its existence from velocity measurements. Dreaming **has been viewed** as the means by which the brain rids itself of unnecessary information. A new **view** from the Hubble Space Telescope shows three well-formed rings around an exploded star. **In view of** all these considerations, the choice of the next logical step in accelerator construction is always a complex issue. We do not hold this **viewpoint**. Experiments involving the use of the above model have been performed **with a view to** gain some insight into the nature of the problem. The operator has a clear **view** standing or sitting.

4. Translate the sentences from Russian into English.

1. В этом исследовании будут учтены все детали (features). В книге даётся подробное описание метода исследования. Такая теория должна учитывать экспериментальные результаты.

2. Общепризнанно, что этот закон имеет силу во всех случаях. Эти данные полностью согласуются с теорией. В то время существовало много разногласий между этими научными школами. Было обнаружено, что данная гипотеза не согласуется с экспериментальными данными. Это значение хорошо согласуется с данными наблюдений (observational data).

3. В своём исследовании они попытались применить новый метод. Применение теории на практике является чрезвычайно важным этапом исследовательской работы. Он только что подал заявление о приёме на работу. Вы собираетесь обратиться в Совет за грантом? Я упомянул несколько случаев, к которым данная теория имеет отношение.

4. В статье будет дан обзор (survey) последних данных. Эти подробности в данном случае нас не интересуют. Большинство гипотез касаются таких механизмов.

5. Нам нужны убедительные доказательства в пользу этой гипотезы. Скоро стало очевидно, что были взяты не те образцы. Есть признаки того, что реакция будет постепенно замедляться. Необходимость в таких преобразованиях самоочевидна. Очевидно, что эти данные нуждаются в тщательной проверке.

6. Основной признак этой теории можно сформулировать следующим образом. Кажется, эти методы имеют много общих особенностей. Конденсатор (capacitor) характеризуется необычайной стабильностью. Отличительные особенности машины перечислены ниже.

7. Теория, которой мы придерживались, не удовлетворяет сегодняшним требованиям. За научными докладами последовало обсуждение. Председатель соблюдал регламент. Это соотношение (relationship) вытекает из законов термодинамики. Из вышеупомянутого следует, что метод открывает (opens up) новые возможности для изучения этого явления. Полученные результаты можно обобщить следующим образом. Следующие примеры могут служить (serve) иллюстрациями (illustrations).

8. Мы полагаем, что эта проблема заслуживает дальнейшего исследования. Была предпринята попытка провести совместное (joint) исследование. Сегодня исследователь должен быть знаком с современными достижениями (developments) в смежных (adjacent) областях науки.

9. Насколько мне известно, этот принцип работает только в исключительных случаях. Нам предстоит заполнить пробелы в знаниях об этом загадочном явлении. Знания, полученные за последние несколько лет, будут успешно использованы.

10. Полученные данные дают исчерпывающее (exhaustive) объяснение структуры этого соединения (compound). Большая часть докладов содержала новую информацию. Проведенные эксперименты дали убедительные доказательства в пользу нашей гипотезы. При выполнении всех условий мы сможем получить желаемый результат.

11. Мы понимаем, что эта реакция может выйти из-под контроля (get out of hand). Если эти условия будут реализованы, мы сможем собрать (assemble) испытательную установку (test installation) в срок. Важно понимать, что у этого метода есть серьёзные недостатки (limitations). Реализация этого проекта требует объединения усилий ученых разных стран.

12. Учитывая это обстоятельство (point), я решил уделить больше внимания (place greater emphasis on) общим принципам моего исследования. Проблемы, которые будут обсуждаться на семинаре, представляют интерес с разных точек зрения. Мы провели эту серию экспериментов с целью определения совпадения новых значений с полученными ранее.

Grammar Focus

Sequence of Tenses. Reported Speech

1. Complete the phrase openings by translating the sentences which follow. Explain when and why no tense changes are necessary in the object subordinate clauses.

It was assumed that	• атомы — элементарные частицы. • нейтроны являются связанными состояниями протонов и электронов. • ядра состоят из двух типов элементарных частиц: электронов и протонов.
It was realized that	• протон и нейтрон — состояния одного типа частиц. • электроны играют двойную роль (dual) в атоме. • космическое излучение является главным (prime) источником информации о новых частицах.

2. Translate the following sentences into English “moving back” the tenses of the subordinate clauses using the general rule according to which “present becomes past and past becomes past perfect”.

1. Ученые сказали, что с нетерпением ждут окончания эксперимента.
2. Он осознавал, что это открытие внесет важный вклад в развитие науки о материалах.
3. Они утверждали, что все важные детали были учтены.
4. Исследователи были уверены, что применили надежный метод сбора данных.
5. Мы были уверены, что реакция протекает без каких-либо осложнений.

6. Они заявили, что полученные результаты плохо согласуются с теоретическими предсказаниями.
7. Было найдено, что значение не изменяется со временем.
8. Он настаивал на том, что необходимо поддерживать (maintain) температуру постоянной в ходе всего эксперимента.
9. Авторы предположили, что проблема будет решена в ближайшее время.

3. Complete the sentences by changing the direct speech to reported speech. Practise using the formal sequence of tenses.

Liying Chen, a rising star in optics, is a PhD candidate at the University of Arizona. She is a recipient of a prestigious award, the Michael Kidger Memorial Scholarship. Here are some excerpts from her interview.

Chen said, "My primary area of interest is imaging science, including optical imaging devices and image processing methods."

Chen said, "What I'm doing now is considering digital radiographic imaging systems."

Chen said, "I'm very satisfied with the path I have chosen. In the last ten years, I've learned a lot."

Chen said, "Three things had the greatest influence on me. The first is my strong background in mathematics and physics, which was my undergraduate major in China. The second was starting my research in optics with Dr. James Wyant. In his lab I found my area of interest and learned all kinds of practical testing skills. The last is working with my advisor Dr. Harry Barret. Under his guidance, I was able to connect my best skills with my interest and have the opportunity to learn the theories."

(from *OE Reports*)

Mind that it is often necessary to make time and place changes in relation to tense changes.

Time:	now two days ago today tomorrow yesterday last night	then two days before that day the next / the following day the previous day / the day before the night before
Place:	here this place these places	there that place those places

4. Study the table with reporting verbs used in paraphrases and summaries. Complete any five sentences started below.

As N	observes / has observed / observed points out remarks says states affirms argues assumes	...
N	believes claims concludes explains finds implies maintains suggests	that...

Other reporting verbs and structures

to add to agree to assert to challenge to clarify	to comment to consider to contradict to demonstrate to deny	to describe to determine to infer to postulate to recommend
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As noted by N...
According to N...
In N's view...

Indirect Questions

5. Study the table with indirect questions.

Question	General	Special
Direct	He asked: "Do you like maths?"	He asked: "What is the matter?"
Indirect	He asked <i>if</i> / <i>whether</i> I liked maths.	He asked <i>what</i> the matter was.

6. Make up indirect questions. Mind the word order.

1. What is every chemical compound made up of? Can you tell me...
2. How do you estimate the information available? Tell me...

3. What do you think of the method applied? I want to know...
 4. How many chemical elements are there? Do you know...
 5. Which of the two procedures do you follow in your research? I'd like to know...
 6. What is the purpose of your paper? Can you tell me...
 7. Have you investigated the subject thoroughly? I wonder ...
 8. Do you agree with his conclusions? I want to know...
 9. Do the data fit well with the observations? It is of interest to know...
7. a) Read excerpts from an interview with the renowned physicist Stephen Hawking published in Time magazine on November 15, 2010. Transform direct questions into reported speech.

If you could talk to Albert Einstein, what would you say? – Ju Huang, STAMFORD, CONN

I would ask him why he didn't believe in black holes. The field equations of his theory of relativity imply that a large star or cloud of gas would collapse in on itself and form a black hole. Einstein was aware of this but somehow managed to convince himself that something like an explosion would always occur to throw off mass and prevent the formation of a black hole. What if there was no explosion?

Do you think our civilization will survive long enough to make the leap to deeper space? – Harvey Bethea, STONE MOUNTAIN, GA

I think we have a good chance of surviving long enough to colonize the solar system. However, there is nowhere else in the solar system as suitable as the Earth, so it is not clear if we would survive if the Earth was made unfit for habitation. To ensure our long-term survival, we need to reach the stars. That will take much longer. Let's hope we can last until then.

Which scientific discovery or advance would you like to see in your lifetime? – Luca Zanzi, ALLSTON, MASS

I would like nuclear fusion to become a practical power source. It would provide an inexhaustible supply of energy, without pollution or global warming.

Does the universe end? If so, what is beyond it? – Paul Pearson, HULL, ENGLAND

Observations indicate that the universe is expanding at an ever increasing rate. It will expand forever, getting emptier and

darker. Although the universe doesn't have an end, it had a beginning in the Big Bang. One might ask what is before that, but the answer is that there is nowhere before the Big Bang, just as there is nowhere south of the South Pole.

Given your reputation as a brilliant physicist, what ordinary interests do you have that might surprise people? – Carol Gilmore, JEFFERSON CITY, MO

I enjoy all forms of music – pop, classical and opera. I also share an interest in Formula One racing with my son Tim.

Do you feel that your physical limitations have helped or hindered your study? – Marianne Vikkula, ESPOO, FINLAND

Although I was unfortunate enough to get motor neuron disease, I have been very fortunate in almost everything else. I was lucky to be working in theoretical physics, one of the few areas in which disability was not a serious handicap, and to hit the jackpot with my popular books.

Does it feel like a huge responsibility to have people expecting you to have all the answers to life's mysteries? – Susan Leslie, BOSTON

I certainly don't have the answers to all life's problems. While physics and mathematics may tell us how the universe began, they are not much use in predicting human behavior because there are far too many equations to solve.

Do you think there will ever come a time when mankind understands all there is to understand about physics? – Karsten Kurze, BAD HONNEF, GERMANY

I hope not. I would be out of a job.

(<http://content.time.com/time/magazine/article/0,9171,2029483,00.html>)

- b) Report the most interesting parts of the interview making good use of the reporting verbs. Decide on the choice of the appropriate tense forms.
- c) Discuss as a class: What question(s) would you ask Hawking if you had a chance to do it? What do you think of Hawking as a man and as a scientist? Have you read any of his popular science books?

Subjunctive I, II. Suppositional. Conditional

1. a) Study the table.

<i>Subjunctive I or Suppositional after</i>	
<i>verbs</i>	<i>impersonal expressions</i>
ask demand insist order require suggest	It is necessary important desirable essential natural unlikely
He suggested that she make a report. (Subjunctive I) He suggested that she should make a report. (Suppositional)	It is necessary that she make a report. (Subjunctive I) It is necessary that she should make a report. (Suppositional)

b) Make up sentences using Subjunctive I or Suppositional.

It is necessary important desirable	that	applied research (should) bring together representatives of interrelated areas fundamental research (should) receive adequate attention cooperation between research centres (should) be encouraged a research lab (should) have excellent equipment a research worker (should) have a substan- tial knowledge of his subject
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2. a) Study the table.

<i>Subjunctive II in "I wish ..." sentences</i>	
<i>refers to the present</i>	<i>refers to the past</i>
1. I wish you were invited to attend the next conference. (= you are not invited) 2. I wish the results were better. (= the results are not as good as they should be) 3. I wish we had more information about the phenomenon. (= we have little or not enough information)	1. I wish you had got in touch with him last week. (= you didn't get in touch) 2. I wish you had made all the necessary alterations long ago. (= you didn't do it) 3. I wish you had sent me a copy of your paper. (= you didn't send it)

b) Translate the sentences into English.

1. Жаль, что этот критерий не удовлетворяется.
2. Жаль, что он не интересуется этой проблемой.
3. Жаль, что эксперимент не удался.

4. Жаль, что ты не посещал наши семинары.
5. Жаль, что ты не выступил на конференции.

3. a) Review the types of conditional sentences.

<i>Condition</i>	<i>Relevance to</i>	<i>If-clause</i>	<i>Main clause</i>
1. Real (true)	the future	If I see him (today / tomorrow)	I will talk to him.
		with Subjunctive II	with Conditional
2. Unreal (possibly true)	the present / future	If I saw him (today / tomorrow)	I would talk to him.
3. Unreal (not true)	the past	If I had seen him (yesterday)	I would have talked to him.

b) Type I conditional sentences. Give full answers to the following questions.

1. What will happen to water if it is cooled below 0°C? (freeze)
2. What will happen to a steel bar if it is heated? (expand)
3. What will happen to ice if it is heated to 0°C? (melt)
4. What will happen if two north poles are brought near each other? (repel)
5. What will happen to oxygen if it is cooled to -182.97°C? (boil)
6. What will happen if oxygen and hydrogen are combined chemically? (form water)
7. What will happen to a steel wire if it is compressed? (decrease in length)
8. What will happen if the north pole of a magnet is brought near the south pole of another magnet? (attract)
9. What will happen to a conductor if an electric current is passed along it? (become hot)

c) Type II conditional sentences. Give suitable answers indicating a possible result. Use the pattern.

- What would happen if a piece of metal were placed in some acid?
 - If a piece of metal were placed in some acid, it would probably react.
1. What would happen if a powder were mixed with some water? (dissolve)
 2. What would happen if a cylinder of gas were heated? (explode)

3. What would happen if a gas were cooled to -180°C ? (liquefy)
4. What would happen if a wire were subjected to a high tensile strength? (snap)
5. What would happen if a piece of metal were heated to 500°C ? (melt)

d) Type III conditional sentences. Express a situation contrary to a past fact. Begin with "This wouldn't have happened if..."

Here is a list of facts:

1. A cylinder of hydrogen exploded.
2. A piece of glass shattered.
3. A glass tube broke into pieces.
4. A bar of steel fractured.
5. A thin copper wire underwent deformation.
6. A coil overheated.
7. A piece of wood burned.
8. Helium condensed into a liquid.

You may use these phrases as prompts:

to heat to too high a temperature
 to bend with an extremely large force
 to pass too high a current
 to heat and cool quickly
 to drop on a cement floor
 to subject to a high tensile force
 to cool to a low enough temperature

4. **Read the text and find all the sentences with subjunctive and conditional forms. Translate them into Russian.**

"If you were starting your career in physics again, which areas of physics would you go into?"

(from a *Physics World* survey)

"It is important that students pay particular attention to two criteria when choosing a research field: having fun, and matching their talents and skills with the work required in that field." That is the advice from astrophysicist John Bahcall from the Institute for Advanced Study in Princeton. And those who replied to our survey appear to have followed his advice, because most seem happy with their careers to date. Indeed, the number of respondents who would

choose the same field of physics again outnumbered those who would try something else by a factor of more than two to one.

It is hard to be categorical, but astronomers and astrophysicists appeared keenest to remain in the same field. "The study of the universe will become the major theme in physics in the 21st century," predicted Nikos Prantzos of the Institut d'Astrophysique in Paris. "Astrophysics is where the action is today," added Lincoln Wolfenstein of Carnegie Mellon University in the US. "There are new discoveries and new problems every year." Martin Rees would remain in the field: "Astrophysics and cosmology have the highest ratio of problems to people, and an impressive rate of discovery at the present time." Astrophysics and cosmology also appealed to many physicists outside the field.

be keen to do smth —
очень хотеть

appeal to — нра-
виться

However, many respondents would prefer to move into the biological sciences because they felt that they could make serious contributions more quickly and more easily in this field than in physics. "The central disciplines of physics are crowded with too many people chasing too few ideas," explained David Thouless. "I would opt for physics applied to some biological subject, where the fashionable ideas are remote from physics."

opt for — выбирать

remote — отдален-
ный

Andre Geim from the University of Nijmegen in the Netherlands selected biophysics or genetics, where, as he put it, "a physicist can really do something in an area where mostly craftsmen work". Ian Aitchison, a theorist at Oxford University, would also choose biology: "The pace there is far quicker, new methods are coming in fast, and the chance of making a serious contribution is higher." Others saw the interface of physics, biology and computing as one of the most promising areas for the 21st century.

craftsman — ремес-
ленник

interface (*n*) — взаи-
мосвязь

But many physicists spoke up eloquently in praise of their own field. "I cannot imagine looking at anything more awe-inspiring than atomic arrangements in materials, or anything so easy to justify as contributing to the economy," enthused Steve Pennycook, an electron microscopist from the Oak Ridge National Laboratory in the US. "I would certainly go into statistical physics again," said Constantino Tsallis of the Brazilian Center for Research in Physics. "Its enormous complexity and richness make it irresistibly fascinating."

John Houghton, who is co-chairman for science assessment on the Intergovernmental Panel on Climate Change, extolled the virtues of environmental physics. The field was, he said, "theoretically and experimentally extremely challenging. It also involves exciting areas of technology, science and computing, and is highly relevant to human society and its future."

Chris Quigg, head of particle theory at Fermilab, praised high-energy physics. "I do think that the best days of particle physics lie ahead, and I wouldn't hesitate to encourage a student — even a young me — to join in."

But the most honest assessment came from John Ziman, emeritus professor at Bristol University in the UK. "I would choose whatever area first captured my interest and attention, because once one gets into them, all fields of research are equally laborious and tedious, and all fields of research are equally fascinating and exhilarating." Who could argue with that?

5. Answer the questions.

1. If you were given a second chance to start university would you sign up for physics again or would you enter another field?
2. What field of physics would you choose as a future career?
3. What would you do to acquire a deeper knowledge in your field?
4. Do you think you could make a discovery in physics?

6. Complete the sentences using the word combinations below.

1. My task might become much simpler if...
 2. I would find a solution to the problem if...
 3. I would feel quite satisfied if...
 4. This could become an epoch-making discovery if...
 5. We would be able to clarify a very important point if...
- to give smth a thorough consideration
 - to have smth at one's disposal
 - to obtain clear evidence of smth
 - there to be sufficient data in current literature about smth
 - to fill in the gap in our knowledge of smth
 - to have detailed information about smth
 - to succeed in finding experimental evidence
 - to employ a new technique

7. Translate the sentences from English into Russian.

1. It would be worthwhile taking a critical look at the concept itself.
2. We would solve the problem if we had more reliable methods of investigation.
3. If they had not failed with their last experiment, they might have done most of the work by now.
4. If we had worked jointly with biologists, we could have had more interesting results.
5. If I had been informed about the symposium long in advance, I could have attended it.
6. Modern research requires that a scientist should be informed about the main investigations in adjacent areas.
7. Many participants insist that the session cover all the points on the agenda.
8. I wish the situation were a little better.
9. You should revise the material lest you forget it.
10. An international centre for theoretical physics was set up so that scientists from various countries might engage in active research.
11. Had we time, we would carry out the experiment.
12. Had it not been for their help, we should have failed in our work.
13. Were this rule obeyed, we would succeed in obtaining reliable results.
14. Were it not for your assistance, we couldn't start the experiment on time.

8. Translate the sentences from Russian into English.

1. Было бы интересно знать, как эти явления взаимодействуют.
2. Было бы естественно напомнить вам об этой проблеме.
3. Было бы своевременно возобновить (renew) наши старые связи с этой лабораторией.
4. Мне потребовалось бы полчаса, чтобы описать все опыты.
5. Эта проблема была бы решена в ближайшее время, если бы в нашем распоряжении были более точные методы.
6. Жаль, что это правило не соблюдается во всех случаях.
7. Если бы только (If only) это допущение было действительно в каждой ситуации.
8. Жаль, что он не провел измерения в соответствии с графиком.
9. Желательно, чтобы вы проверили полученные результаты еще раз.
10. Важно, чтобы ученые получили больше доказательств в пользу этой гипотезы.
11. Будь у нас время, мы бы провели новую серию экспериментов.
12. Если бы не (But for) финансовые трудности, мы смогли бы переоборудовать нашу лабораторию уже сейчас.

Participle

1. Study the table with the forms of the Participle.

	<i>Active</i>	<i>Passive</i>
Present (Participle I)	giving	being given
Past (Participle II)	—	given
Perfect	having given	having been given

2. Review the main functions of the Participle.

1. attribute A molecule is a compound <i>consisting</i> of two or more atoms. The substance <i>being investigated</i> is first weighed.	Молекула — это соединение, <i>состоящее</i> из двух или более атомов. <i>Исследуемое</i> вещество сначала взвешивается.
--	--

Phenomena <i>occurring</i> in particle collisions were thoroughly investigated.	Явления, <i>происходившие</i> (которые происходили) в процессе столкновения частиц, тщательно исследовались.
The <i>performed</i> work showed good results.	<i>Проведенная</i> работа дала хорошие результаты.
The experiment <i>made</i> in our laboratory was a failure.	Эксперимент, <i>проведенный</i> (который был проведен) в нашей лаборатории, оказался неудачным.
The paper <i>referred to</i> is very informative.	Статья, <i>на которую ссылаются</i> , очень информативна.
2. adverbial modifier	
(When / While) <i>carrying out</i> the experiment, the scientist made an error in the calculations.	<i>Проводя</i> опыт, ученый сделал ошибку в вычислениях. (<i>При проведении</i> опыта ученый сделал... <i>Когда</i> ученый проводил опыт, ...)
<i>Having made</i> the measurements, the experimenter began to process the data.	<i>Проведя</i> измерения, экспериментатор начал обрабатывать данные. (<i>После того как</i> экспериментатор провел измерения, он начал...)
<i>Being exposed</i> to X-rays, this substance emits light.	<i>Под воздействием</i> рентгеновских лучей это вещество испускает свет. (<i>Если</i> на вещество <i>воздействуют</i> рентгеновские лучи, оно...)
<i>Having been published</i> in an international journal, this article became widely known.	<i>После того как</i> эту статью <i>опубликовали</i> в иностранном журнале, она стала широко известна.
<i>Considered</i> from this point of view, the problem will be of great interest.	<i>При рассмотрении</i> с этой точки зрения задача будет представлять большой интерес. (<i>Если</i> задачу <i>рассматривать</i> с этой точки зрения...)

Memorise the following word combinations used as parenthesis.

unless otherwise stated
as emphasized above
as already mentioned
as pointed out previously
as stated above
roughly speaking
generally speaking
strictly speaking
put another way/ putting it
another way

если не оговорено особо
как подчеркивалось выше
как уже упоминалось
как ранее указывалось
как указано выше
грубо говоря
вообще говоря
строго говоря
иначе говоря, другими словами

Note: given (*conj*) — если дан, если имеется, если известен
provided (that)/providing (that) (*conj*) — при условии,
если

3. Identify the functions of the Participle and translate the sentences into Russian.

1. I shall give a review of papers covering the most important problems in this area.
2. The table shows, as mentioned above, that these equations form an adequate basis for our investigation.
3. In this paper we survey the possibilities arising from the application of new high-precision instruments.
4. Our research is primarily concerned with the events accompanying solar flares.
5. Introducing a new method, he pointed out its possible applications.
6. The transformations taking place in such reactions have been listed in a number of works.
7. Some six percent of the mass disappeared having been transformed into energy.
8. We must have devices improving the accuracy of measurements.
9. As emphasized above, the relation considered in this paper does not hold for all the cases.
10. The notation used in this equation is described at the beginning of the article.
11. If desired, the instrument may be used repeatedly.
12. The method applied increased the accuracy of the results.
13. It was a standpoint shared by many scientists at the end of the 20th century.
14. When heated, the liquid occupies a larger volume.
15. The data obtained disagreed with earlier findings.

4. Translate the sentences into English using the Participle where appropriate.

1. В этой статье будут приведены экспериментальные данные, подтверждающие наше предположение.
2. Значительное внимание будет уделено условиям, приводящим к образованию такой сложной структуры.
3. Фундаментальные исследования, касающиеся природы этого явления, проводятся во многих научных центрах.
4. Трудности, возникающие в ходе такого исследования, могут быть значительными.

5. Доводы, приведенные в статье, не противоречат основным положениям существующей теории.
6. Рассматриваемая теория хорошо согласуется с результатами, полученными ранее.
7. Строго говоря, в пределах точности описываемых результатов наша теория остается достоверной.
8. Полученные данные указывают на существование общего механизма, лежащего в основе этих изменений.
9. Сопоставив наши результаты с теоретическими расчетами, мы обнаружили небольшое отклонение.
10. При выводе этого уравнения нам следует учитывать ряд важных факторов.
11. Если не оговорено особо, этой величиной можно пренебречь.
12. После приведения в действие (bring into operation) установка позволила получать частицы с еще более высокой энергией.

5. a) Study the table with the Absolute Participial Construction. Notice how it is translated into Russian.

<i>The decision having been made, we considered the next item on the agenda.</i>	<i>После того как решение было принято, мы рассмотрели следующий пункт повестки дня.</i>
<i>The results lacking precision, we had to apply a new method.</i>	<i>Поскольку результатам не хватало точности, нам пришлось применить другой метод.</i>
<i>With all the equipment installed, we could start the experiment.</i>	<i>Когда все оборудование установили, мы смогли начать эксперимент.</i>
<i>There being no alternative suggestions, we accepted their plan.</i>	<i>Ввиду отсутствия альтернативных предложений мы приняли их план.</i>
<i>The results are quite reliable, some of them being of particular interest to engineers.</i>	<i>Данные результаты довольно надежные, при этом некоторые из них представляют особый интерес для инженеров.</i>

b) Read the passage and identify the sentences with the Absolute Participial Construction. Translate the passage in writing.

The greenhouse effect

The greenhouse effect is a mechanism causing warming of the surface and lower atmosphere of the Earth or other planets. The surface, heated by solar radiation (especially in the visible part of the spectrum at wavelengths of 0.4–0.8 μm), reaches

a stable temperature regulated by the fraction of solar radiation reflected, known as the albedo (of the order of 0.3 for the Earth), the rest being absorbed and converted into thermal energy. For Earth, this equilibrium temperature is 255°K (-18°C), at this temperature a black body (absorbing all incident electromagnetic energy) emits mainly in the infrared ($\lambda > 1\ \mu\text{m}$). In the case of the Earth, the infrared radiation emitted from the surface is absorbed by two atmospheric gases: water vapour and carbon dioxide. The absorption of surface radiation by the lower atmosphere in turn contributes to the warming of the surface, and the process is amplified. This is known as the greenhouse effect, so called because it is analogous to the mechanism whereby a greenhouse is heated, its glass playing the role of the lower atmosphere and letting through the visible radiation but blocking the infrared. On Earth, this involves a heating effect of 33°C — a modest value kept constant by a self-regulatory mechanism involving the oceans. The phenomenon is less marked on Mars (4°C), but it was undoubtedly much more important in the past. On Venus, the effect is dramatic. The surface heated to a temperature of 730°K (more than 450°C), showing how the mechanism can run wild if no regulation is present. This illustrates the threat to the Earth's climate posed by increased quantities of carbon dioxide, if humans continue to produce it at current rates.

Supplementary material for reading and discussion

Which five physicists have made the most important contributions to physics?

Some scientists are great because they are good all-rounders. Others make a major discovery by accident, but are not especially brilliant — just lucky. Others are brilliant, but never have a big discovery, although they can be immensely influential behind the scenes. It was with these words of warning from Paul Davies that we added up the answers to this question in the *Physics World* office.

A total of 61 physicists received at least one vote, but it will come as no surprise to see Albert Einstein at the top of our list with 119 votes. Einstein's development of the special and general theories of relativity changed physics forever by revolutionizing the way in which we view space and time. Even one of his other "lesser" achievements, such as the explanation of the

photoelectric effect, would have been enough to secure his reputation as one of the leading scientists of all time.

In second place with 96 votes is Isaac Newton — the man whose laws of mechanics and gravitation form the basis of vast swathes of classical physics, and who contributed much to the fields of optics, light and heat. Newton may have received fewer votes than Einstein because some respondents preferred to restrict their choices to scientists from the 20th century. Others felt that Galileo (6th in the list) deserved credit for paving the way for Newton's discoveries.

In third place is the Scottish physicist James Clerk Maxwell, who expressed in his four famous equations two centuries of experimental discoveries in electricity and magnetism, and who successfully unified the two phenomena into one — electromagnetism. Although he mistakenly believed that electromagnetic radiation was carried through an invisible "ether", Maxwell's equations still remained valid even when Einstein's theories disproved the notion of an ether. Maxwell also played a key role in the development of the kinetic theory of gases, as did his contemporary Ludwig Boltzmann (joint 11th), who laid the foundations of statistical physics, devised the notion of "entropy", and did much to show that all matter is made from atoms.

The top 15 includes five physicists who worked on the development of quantum mechanics in the early part of the 20th century — Niels Bohr (4th), Werner Heisenberg (5th), Paul Dirac and Erwin Schrödinger (joint 8th) and Max Planck (11th). However, many respondents found it hard to select one individual from this group. Nobel prize winning particle theorist Steven Weinberg, who himself received two votes, went for Schrödinger. "He is really a stand-in for all the physicists who contributed to the discovery of quantum mechanics. I chose Schrödinger because it is his approach that turned out to be most useful."

Although Dirac successfully developed relativistic quantum theory and predicted antimatter, it is Bohr who comes top of this sub-group — his 47 votes putting him 4th in the *Physics World* list. Bohr realized that the orbits of electrons in an atom are quantized, and although he stuck to his "semi-classical" view of the atom for many years, he inspired both Heisenberg and Schrödinger in the development of the matrix- and wave-mechanics versions of quantum theory. Bohr also contributed to the philosophical implications of physics, although his "Copenhagen interpretation" of quantum mechanics, which many physicists

felt was the final word on the matter for many years, is increasingly being seen as inadequate.

Bohr's early work was carried out as a post-doc at Manchester University with Ernest Rutherford (10th in the list), whose famous experiments on the scattering of alpha particles from gold films showed that atoms have a nucleus. Rutherford's work opened the door to the whole field of nuclear physics — and eventually to the development of nuclear energy and weapons by, among others, the Italian all-rounder Enrico Fermi (14th).

Marie Curie, who discovered the elements radium and polonium as well as making many other contributions in nuclear physics, comes 15th on the list with six votes. The only other woman to receive a vote was Cecilia Payne-Gaposhkin, the British-born astrophysicist who discovered that stars are amazingly uniform in their composition and that hydrogen is millions of times more abundant than any other element in the universe.

The most modern physicist in the top 15 is Richard Feynman (7th), who died in 1988 and who did much to develop our understanding of quantum electrodynamics — the quantum theory of the electromagnetic interaction. The final berth in the top 15 goes to Michael Faraday (joint 11th with Boltzmann), who in 1821 discovered that a wire carrying a current could be made to rotate in a magnetic field. His discovery paved the way for the development of both Maxwell's theory of electromagnetism and the motor, which forms the basis of most of modern industry.

Of the 61 physicists voted for by respondents, 11 are still alive today. The nuclear physicist Hans Bethe leads this group with 3 points. But what about Einstein himself? Which physicists did he admire the most? According to the archives, his top three physicists were all British: Newton, Faraday and Maxwell.

(from *Physics World*, 1999)

Discussion points

1. Which physicist do you consider most prominent? Give your reasons.
2. What makes a great scientist?

You may begin your answers with the words:

In my opinion...	To my knowledge...
To my mind...	As far as I can judge...
From my point of view...	As far as I know...

Physics problems for fun

Think about possible answers to the problems below.

1. The mysterious whispering gallery

It was Rayleigh who first explained the mysterious whispering gallery in the dome of London's St. Paul's Cathedral. In this large gallery there is a peculiar audibility for whispers. For instance, if a friend were to whisper to the wall somewhere around the gallery, you would be able to hear his whisper no matter where you might stand along the gallery (Figure 1). Strangely enough, you will hear him better the more he faces the wall and the closer he is to it.

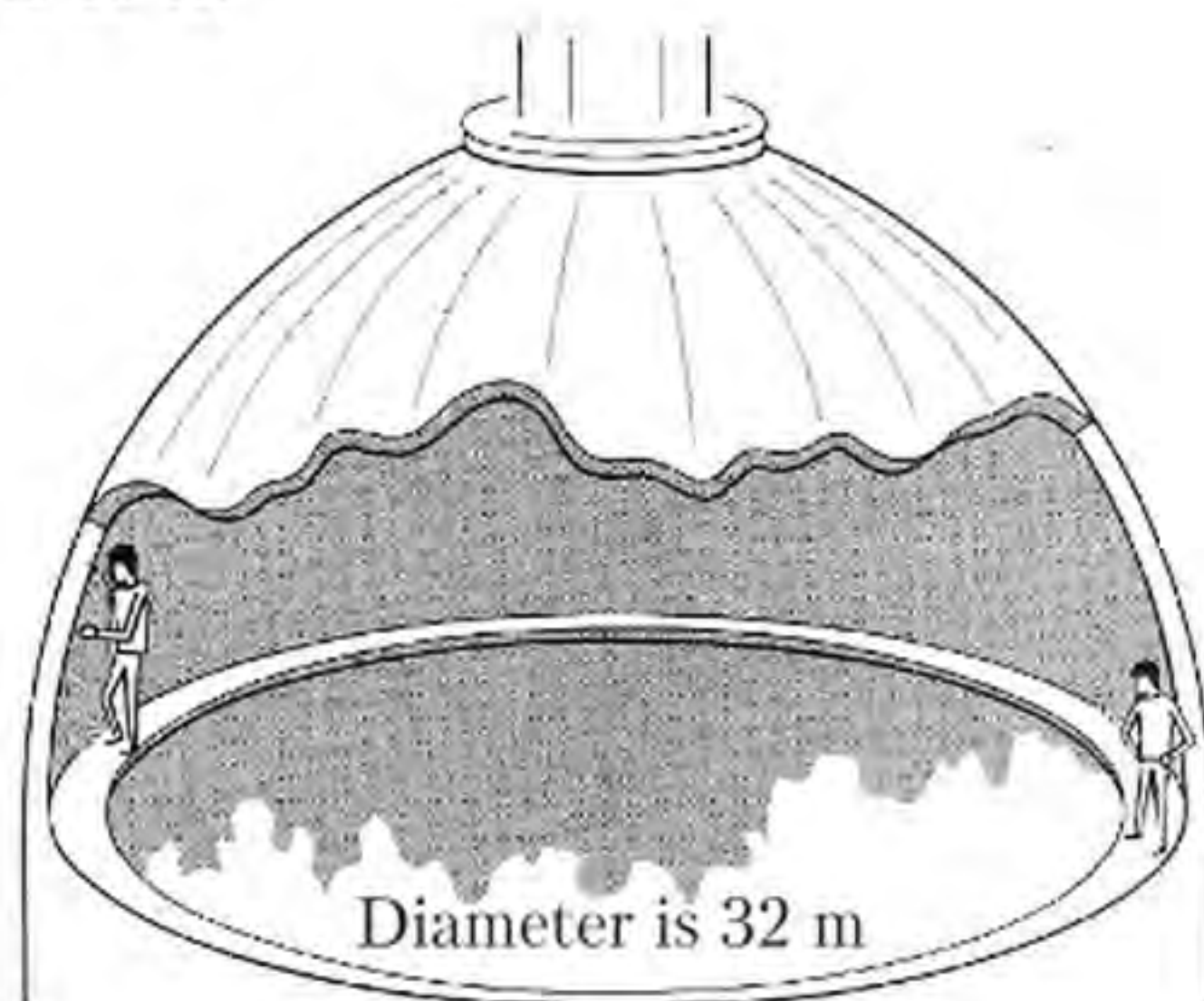


Fig. 1

Is this just a straightforward reflection and focusing problem? Rayleigh made a large model of the gallery to find out. He placed a birdcall at one point along the model gallery and a flame at another point. When sound waves from the birdcall impinged on the flame, the flame would flare, and so the flame was his sound detector. You are probably tempted to draw the sound rays shown in Figure 2. But before you put too much faith in them, suppose a narrow screen were to be placed at some intermediate point along the inside perimeter of the metal sheet (as shown in Figure 3), but exactly where along the perimeter doesn't matter. If your idea about the rays is correct, the flame should still flare because the screen is out of the way, right? Well, as a matter of fact, when Rayleigh

inserted a screen, the flame did not flare. The screen must somehow have blocked the sound waves. But how? After all, it was only a narrow screen placed seemingly well out of the way of the sound rays. This result gave Rayleigh a clue to the nature of the whispering gallery.

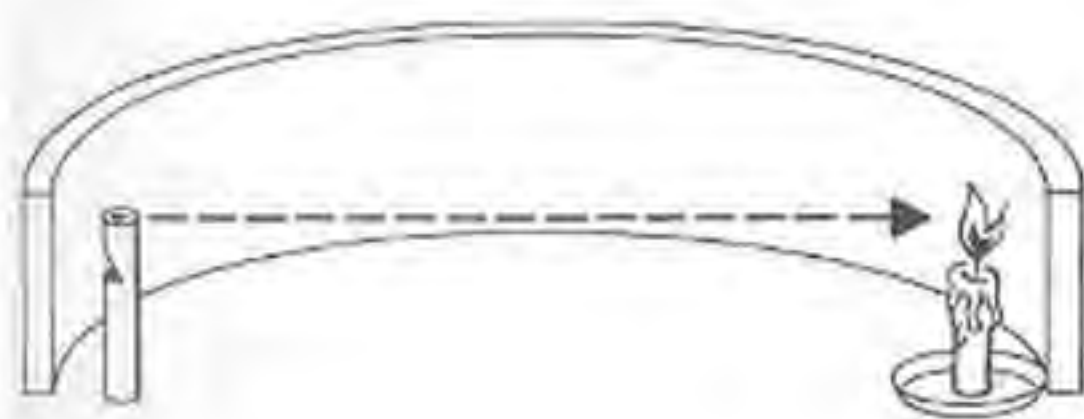


Fig. 2

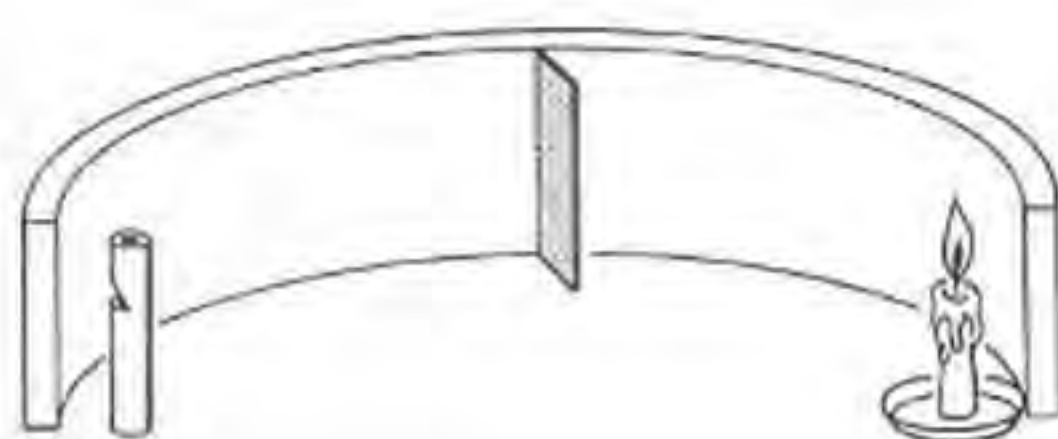


Fig. 3

2. Silent zones of an explosion

During World War II it was often noticed that as one would drive toward a distant artillery piece, the roar of its fire would disappear at certain distances. Why were there such silent zones? Sound travel over large distances is also curious. For example, during World War I people on the English shore could hear gunfire from installations in France. What conditions permit such an enormous sound range?

3. Nuclear-blast fireball

What exactly causes the fireball, that brilliant ball of light, in a nuclear blast? That is, what produces the light? How long does the fireball last, and what causes its decay? Finally, why is it initially red or reddish-brown and later white?

(from the *Flying Circus of Physics* by J. Walker)

Unit V

SCIENCE AND TECHNOLOGY

Grammar Skills	Modal Verbs. Gerund. Types of Sentences Reading and Speaking. Writing: Paraphrasing, Summarising and Note-making. Information Transfer: Presenting Graphs, Diagrams, etc. Critical Thinking
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Speaking

1. Comment on the following statements. You may agree or disagree. Give your reasons.

a) Science is the force that should be used for the good of humanity.

b) Science is a chain reaction, and it might be disastrous to suppress a discovery, however trivial, which might one day be a vital missing link.

c) Scientist's responsibility is to science, his duty is to discover as much as he can about man and the universe. The use that may be made of his discoveries rests squarely on the shoulders of society.

d) Science is the art of the soluble. A good scientist knows the trick is to choose a problem that is ripe for solution, both because the technology is there and because the concepts are in place. This explains the abundance of examples of simultaneous discoveries in the history of science.

The following expressions might be useful to you.

That's right.

Quite true.

Right.

Quite right.

Not quite right.

Just the opposite, I'm afraid.

Just on the contrary, I'm afraid.

It's not quite so.

2. Read the microtext below. Give examples of high-tech and low-tech products and of leading-edge technologies.

Technology is scientific knowledge applied for practical purposes.

Some technologies are more complex than others. Products, systems or industries using advanced technologies are high-technology, high-tech, or hi-tech. Those at the other end of the scale are low-technology or low-tech.

The most advanced products and systems are said to be at the leading edge of technology or to represent the state of the art (уровень развития в какой-либо области науки и техники).

3. Read the text and say whether you agree or disagree with the author's viewpoint.

It is a commonplace that technologies move only slowly from first invention to widespread use. What is striking in the history of technological innovation, however, is that the dispersion of a new technology is not just slow but extraordinarily uncertain even after its first commercial applications have been realised.

This runs against the conventional wisdom, which holds that uncertainties are much reduced after the first commercial use. The evidence to refute that view comes not just from any old technologies, but from many of the most important innovations of the 20th century.

Consider the laser, a comparatively young technology with more development in store. Beyond uses in measurement, navigation and chemical research, applications have expanded to include the reproduction of music (to make the laser a household product); surgery; printing; the cutting of cloth and other materials; and, its most significant use of date, telecommunications.

Together with fibre optics, the laser has revolutionised the telephone business, yet lawyers at Bell Labs were initially unwilling even to apply for a patent for their invention, believing it had no relevance to the telephone industry.

If that story sounds familiar, there is a reason: such a pattern of innovation is not exceptional, nor even quite common, but typical. The steam engine was invented in the 18th century as a way of pumping water out of mines; it remained nothing more than a pump for many years. Then it became a source of power for industry, then a source of power for transport, then a way to generate electricity. The first inventors never dreamed of such a breadth of application (or of electricity, for that matter).

(from *Key Words in Science and Technology*)

Could you think of other innovations that follow the pattern described by the author?

4. Comment on the statement.

Technology has made the world much smaller.

Reading

Pre-text exercises

1. Check whether you pronounce these words correctly.

accelerator [æk'seləreɪtə]

cathode [ˈkæθəʊd]

coarse [kɔ:s]

colleague [ˈkɒli:g]

collider [kəˈlaɪdə]

component [kəmˈpəʊnənt]

decade [ˈdekeɪd], [dɪˈkeɪd]

determine [dɪˈtɜ:mɪn]

electrode [ɪˈlektroʊd]

elusive [ɪˈlu:sɪv]

machine [məˈʃi:n]

originally [əˈrɪdʒ(ə)nəli]

kaon [ˈkeɪɒn]

meson [ˈmi:zɒn], [ˈmeɪzɒn]

occurrence [əˈkʌrəns]

pion [ˈpaɪɒn]

quantum [ˈkwɒntəm]

ratio [ˈreɪʃiəʊ]

subtle [ˈsʌtl]

sufficient [səˈfɪʃnt]

surmise [səˈmaɪz]

target [ˈtɑ:ɡɪt]

trajectory [trəˈdʒektəri],
[ˈtrædʒɪktəri]

2. Practise reading the following words and word combinations. Memorise the use of prepositions and articles.

a) electron, instrument, accelerator, colleague, quark, electrode,
manipulate, determine, property, target, impact, subtle, law,
indispensable, quest, momentum, nature, although, cathode,
entrench, precisely, experiment, positron, muon, pion, kaon,
coarse, argue, surmise, existence, decade, originally, collider,
collision, revelation, fundamentally, machine

b) electric potential, resulting beam, magnetic field, charge-to-mass ratio, cathode rays, physical principle, key tool, subatomic particle, natural radioactive source, cosmic rays, elusive object, accelerator-based experiment, vector meson, available energy, colliding particles, physical trajectory, associated wave

c) to apply a difference **in** electric potential **to** ..., to manipulate the resulting beam **with** electric and magnetic fields, to determine the charge-to-mass ratio **of** cathode rays, to study the properties **of** the beam, impact **on** a target, to become indispensable, **at** smaller scales, to operate **on** (much) the same principles, to become entrenched **as** the key tool, **in** the search **for** subatomic particles, to be largely based **on** natural radioactive sources, the existence **of** the atomic nucleus, to be surmised **from** the existence **of** charged pions, occurrence **of** gamma rays **in** cosmic rays, to give preliminary evidence **for** ..., to nail down the existence **of** ..., two decades **of** accelerator-based discoveries **of** other subatomic particles, composites **of** quarks, to enter the picture, new revelations **in** particle physics, the evolution **of** accelerator and collider technology, to provide available energy, to stand **at** the forefront **of** "particle physics" research, the main objects **of** study, the reasons **for** high energy, **under** the laws **of** quantum mechanics, to be localized **at** a given point **in** space and time, the wavelength **of** a probing particle, **at** extremely small distances, the scale **of** things, **in** the range **of**, another reason **for** using ..., most **of** the objects **of** interest **to** ..., the key **to** understanding

3. Pronunciation check. Find the odd word. Make sure you know how to pronounce the vowel sounds.

1. call, small, scale, tall
2. charge, large, care, far, part
3. source, more, cause, search, law, short, coarse
4. ray, say, nail, wave, space, want, main, way, same
5. beam, need, heat, great, key, reason
6. close, whose, both, most
7. high, since, time, try, like, might
8. such, under, but, study, use

Pre-reading task

Skim through the text below to get a general idea of its content and define the subject matter of the text.

1. When J.J. Thomson discovered the electron, he did not call the instrument he was using an accelerator, but an accelerator it certainly was. He accelerated particles between two electrodes to which he had applied a difference in electric potential.

He manipulated the resulting beam with electric and magnetic fields to determine the charge-to-mass ratio of cathode rays. Thomson achieved his discovery by studying the properties of the beam itself — not its impact on a target or another beam, as we do today. Accelerators have since become indispensable in the quest to understand Nature at smaller and smaller scales. And although they are much bigger and far more complex, they still operate on much the same physical principles as Thomson's device.

beam — луч, пучок

impact (*n*) — воздействие

target (*n*) — мишень, цель

indispensable — незаменимый, необходимый

quest — поиск

2. It took another half century, however, before accelerators became entrenched as the key tools in the search for subatomic particles. Before that, experiments were largely based on natural radioactive sources and cosmic rays. Ernest Rutherford and his colleagues established the existence of the atomic nucleus — as well as of protons and neutrons — using radioactive sources. The positron, muon, charged pions and kaons were discovered in cosmic rays.

become entrenched — укореняться

search — поиск

as well as — так же, как

3. One might argue that the second subatomic particle discovered at an accelerator was the neutral pion, but even here the story is more complex. That it existed had already been surmised from the existence of charged pions, and the occurrence of gamma rays in cosmic rays gave preliminary evidence for such a particle. But it was an accelerator-based experiment that truly nailed down the existence of this elusive object.

argue — утверждать

surmise — предполагать

nailed down — подкрепить, закрепить

elusive — неуловимый

originally — первоначально

notably — особенно

turn out — оказываться

4. There followed almost two decades of accelerator-based discoveries of other subatomic particles originally thought to be elementary, notably the antiproton and the vector mesons. Most of these particles have since turned out to be composites of quarks. After 1970 colliders — machines using two accelerator beams in collision — entered

the picture. Since then most, but certainly not all, new revelations in particle physics have come from these colliders.

revelation — открытие

5. In considering the evolution of accelerator and collider technology, we usually think first of the available energy such tools provide. Fundamentally, this is the way it should be. When the study of the atomic nucleus stood at the forefront of "particle physics" research, sufficient energy was needed to allow two nuclei — which are positively charged and therefore repel one another — to be brought close enough to interact. Today, when the components of these nuclei are the main objects of study, the reasons for high energy are more subtle. Under the laws of quantum mechanics, particles can be described both by their physical trajectory as well as through an associated wave whose behavior gives the probability that a particle can be localized at a given point in space and time. If the wavelength of a particle is short, matter can be examined at extremely small distances; if long, then the scale of things that can be investigated will be coarser. Quantum mechanics relates this wavelength to the energy (or, more precisely, the momentum) of the colliding particles: the greater the energy, the shorter the wavelength.

fundamentally — по существу

subtle — тонкий

scale — масштаб

coarse — крупный

6. This relationship can be expressed quantitatively to examine matter at the scale of an atom (about 10^{-8} centimeter), the energies required are in the range of a thousand electron volts. (An electron volt is the energy unit customarily used by particle physicists; it is the energy a particle acquires when it is accelerated across a potential difference of one volt.) At the scale of the nucleus, energies in the million electron volt — or MeV — range are needed.

relationship — соотношение, зависимость

range (*n*) — диапазон

customarily — обычно

To examine the fine structure of the basic constituents of matter requires energies generally exceeding a billion electron volts, or 1 GeV.

fine — тонкий
constituent — состав-
ная часть, составля-
ющая

7. But there is another reason for using high energy. Most of the objects of interest to the elementary particle physicist today do not exist as free particles in Nature: they have to be created artificially in the laboratory. The famous $E=mc^2$ relationship governs the collision energy E required to produce a particle of mass m . Many of the most interesting particles are so heavy that collision energies of many GeV are needed to create them. In fact, the key to understanding the origins of many parameters, including the masses of the known particles, required to make today's theories consistent is believed to reside in the attainment of collision energies in the trillion electron volt, or TeV, range.

govern — описывать

origin — происхож-
дение

consistent — последо-
вательный

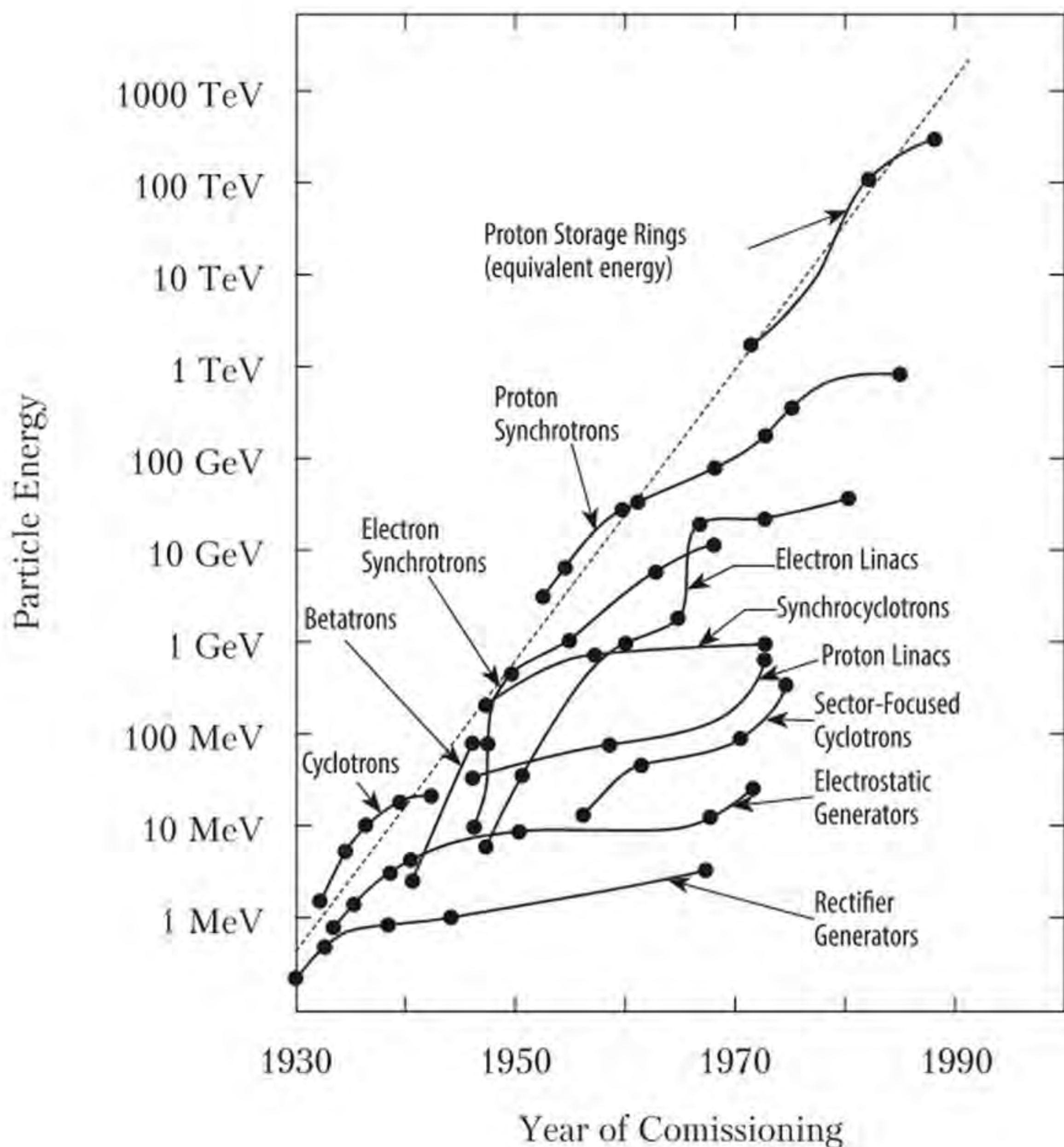
reside — находиться

8. Our progress in attaining ever higher collision energy has indeed been impressive. The graph, originally produced by M. Stanley Livingston in 1954, shows how the laboratory energy of the particle beams produced by accelerators has increased. This plot has been updated by adding modern developments. One of the first things to notice is that the energy of man-made accelerators has been growing exponentially in time. Starting from the 1930s, the energy has increased — roughly speaking — by about a factor of 10 every six to eight years. A second conclusion is that this spectacular achievement has resulted from a succession of technologies rather than from construction of bigger and better machines of a given type. When any one technology ran out of steam, a successor technology usually took over.

attain — достигать

spectacular —
потрясающий
succession — ряд

successor —
преемник



(from *Evolution of Particle Accelerators and Colliders*
by Wolfgang K.H. Panofsky)

Mind the following abbreviations.

MeV – megaelectronvolt	mega [ˈmega] M, 10^6
GeV – gigaelectronvolt	giga [ˈgɪɡə] G, 10^9
TeV – teraelectronvolt	tera [ˈterə] T, 10^{12}

Interacting with the text

1. Read the text again and decide which of the following best explains the message of the whole extract.

The author is trying to

- a) describe an accelerator-based experiment
- b) account for the evolution of accelerators and colliders

- c) trace the development of accelerator and collider technology
 - d) focus on the discovery of the electron
 - e) highlight the importance of the study of the atomic nucleus
2. a) Make a mental note of the main idea(s) in each paragraph. As you read through the article, you gradually build on your understanding of the author's message.

Can you recognise the main idea in the first paragraph?

What heading would you suggest for it?

Compare your heading with those of other students.

- b) Choose the most suitable headings for the rest of the paragraphs from the list below. Give reasons for your choice. Mind that there are more headings than paragraphs.

List of headings

1. Natural radioactive sources and cosmic rays.
2. The study of the atomic nucleus.
3. The search for subatomic particles.
4. Energies at the scale of the nucleus.
5. Colliders and new discoveries in particle physics.
6. The laws of quantum mechanics.
7. The greater the energy, the shorter the wavelength.
8. The role of high energy in studying subatomic particles.
9. Accelerator-based experiments.
10. The attainment of collision energies.
11. Modern developments in accelerator technology.
12. Spectacular achievements in collider technology.
13. Successor technologies.

Developing Skills of Paraphrasing

***Paraphrasing** is using your own words to report someone else's writing, but maintaining an academic style.*

Rewriting a text in your own words can be done in several ways:

- **by changing the vocabulary** (verbs / nouns)
- e.g. Accelerators have become indispensable...
*Accelerators have become **most important**...*
 It had already been surmised...
*It had already been **assumed**...*
 An experiment nailed down...
*An experiment **proved**...*

New revelations in particle physics...
*New **discoveries** in particle physics...*
A succession of technologies...
*A **series** of technologies...*

1. Rewrite the following:

Accelerators *became entrenched as...*

Colliders *entered the picture...*

When any one technology *ran out of steam*, a successor technology took over.

- **by changing the verb form** (e.g. from active to passive thus changing the focus or emphasis)

e.g. Ernest Rutherford and his colleagues **established** the existence of the atomic nucleus.

*The existence of the atomic nucleus **was established** by Ernest Rutherford and his colleagues.*

2. Rewrite the following:

To examine the fine structure of the basic constituents of matter **requires** energies generally exceeding a billion electron volts.

- **by changing the word class** (e.g. from verb to noun phrase)

e.g. That *it existed* had already been surmised from...

Its existence had already been surmised from...

Changing the word class allows you to add your own comments.

e.g. The positron, muon, charged pions and kaons **were discovered** in cosmic rays.

*The **discovery** of positron, muon, charged pions and kaons in cosmic rays was an important achievement.*

3. Rewrite the following:

Accelerators still operate on much the same physical principle as Thomson's device.

The principle of operation...

- **by synthesis** (by combining two or more sentences, viewpoints or pieces of information)

e.g. When J.J. Thomson discovered the electron, he did not call the instrument he was using an accelerator, but an accelerator it certainly was. He accelerated particles between two electrodes to which he had applied a difference in electric potential. He manipulated the resulting beam with electric and magnetic fields to determine the charge-to-mass ratio of cathode rays. Thomson achieved his discovery by studying the properties of the beam it-

self – not its impact on a target or another beam, as we do today. Accelerators have since become indispensable in the quest to understand Nature at smaller and smaller scales. And although they are much bigger and far more complex, they still operate on much the same physical principles as Thomson’s device.

The device used by Thomson in his famous “discovery” experiment to accelerate particles has much in common with modern accelerators. In fact they operate on practically the same physical principles.

4. Look through paragraph 2 and combine the ideas expressed in one or two sentences.

Before accelerators came into use (became widely used)...

Note-making

To write effectively you must be able to make effective notes. You must be able to recognise main or relevant ideas in a text and be able to reproduce these in note form.

One of the ways of setting down information is to use a “mind map”.

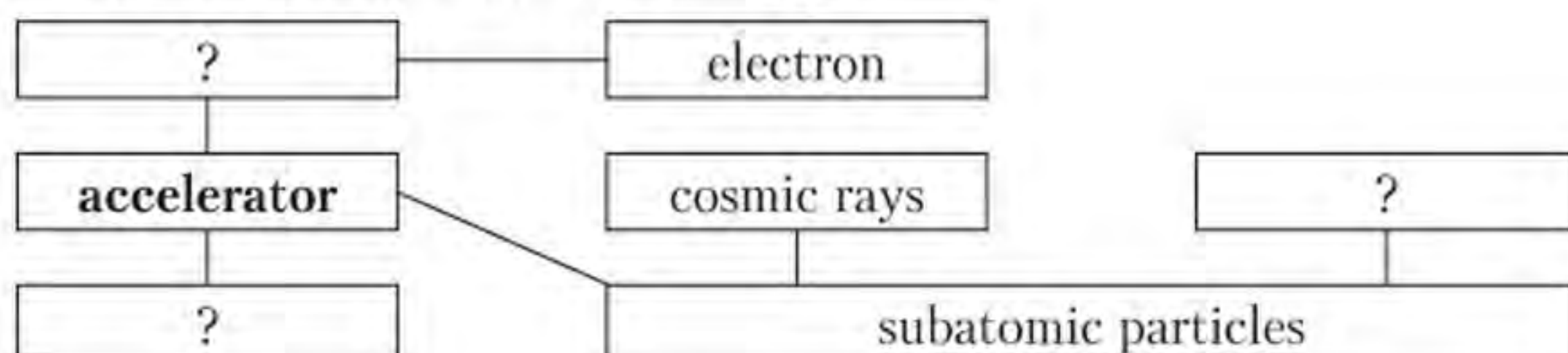
In this case you write down the central fact or idea in the middle of the page and connect it to other facts and ideas using “key words”. A “key word” helps you to remember information.

Summarising

Begin your summary by restating the main idea. Mention other major points. Change the order of points if necessary. Re-read the work to check that you have included all the important information clearly.

In a summary you should not include your own opinions or extra information on the topic which is not in the text you have read. You are summarising only the writer’s information. Also take care not to include details of secondary importance.

1. Read through paragraphs 1–4 identifying the keywords and complete the “mind map” started below. You will need the information as a basis for a summary.



You may try to represent the information in a different way.

2. Write the summary of paragraphs 1–4. Choose the most suitable beginning from the box below or think of another one. Use the skills of paraphrasing.

The existence of subatomic particles...
 It was the accelerator and collider technology that...
 Particle physics owes its important discoveries to...
 Thomson's device...
 The search for subatomic particles...

3. Recognise the main ideas in paragraphs 5–8 and reproduce them in the form of a “mind map”. Summarise the information in 4–5 sentences.
4. Now retell the text about accelerators using the headings of paragraphs 1–8 as an outline.

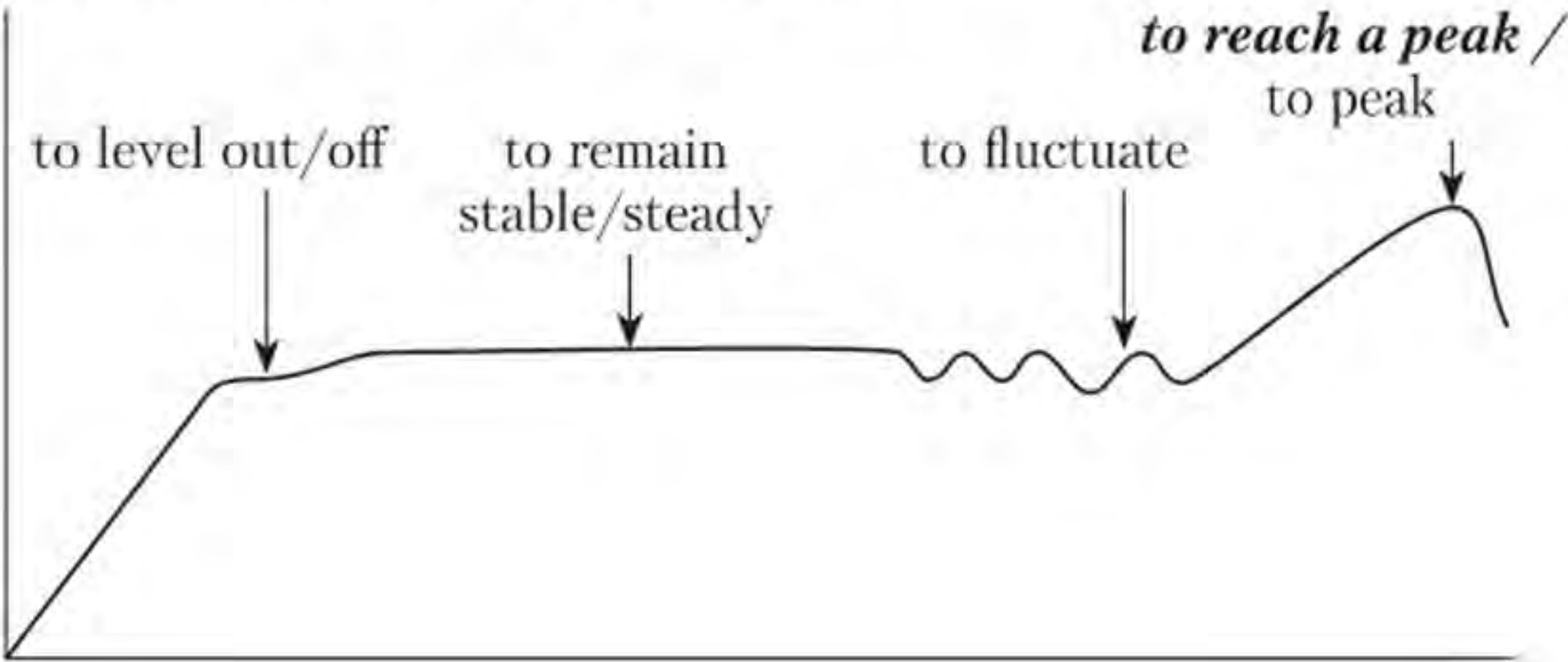
Interpretation of Data

Information in charts and diagrams usually requires some comment. Not all the information should be described. Introduce the information with a general comment and then draw attention to the most significant items.

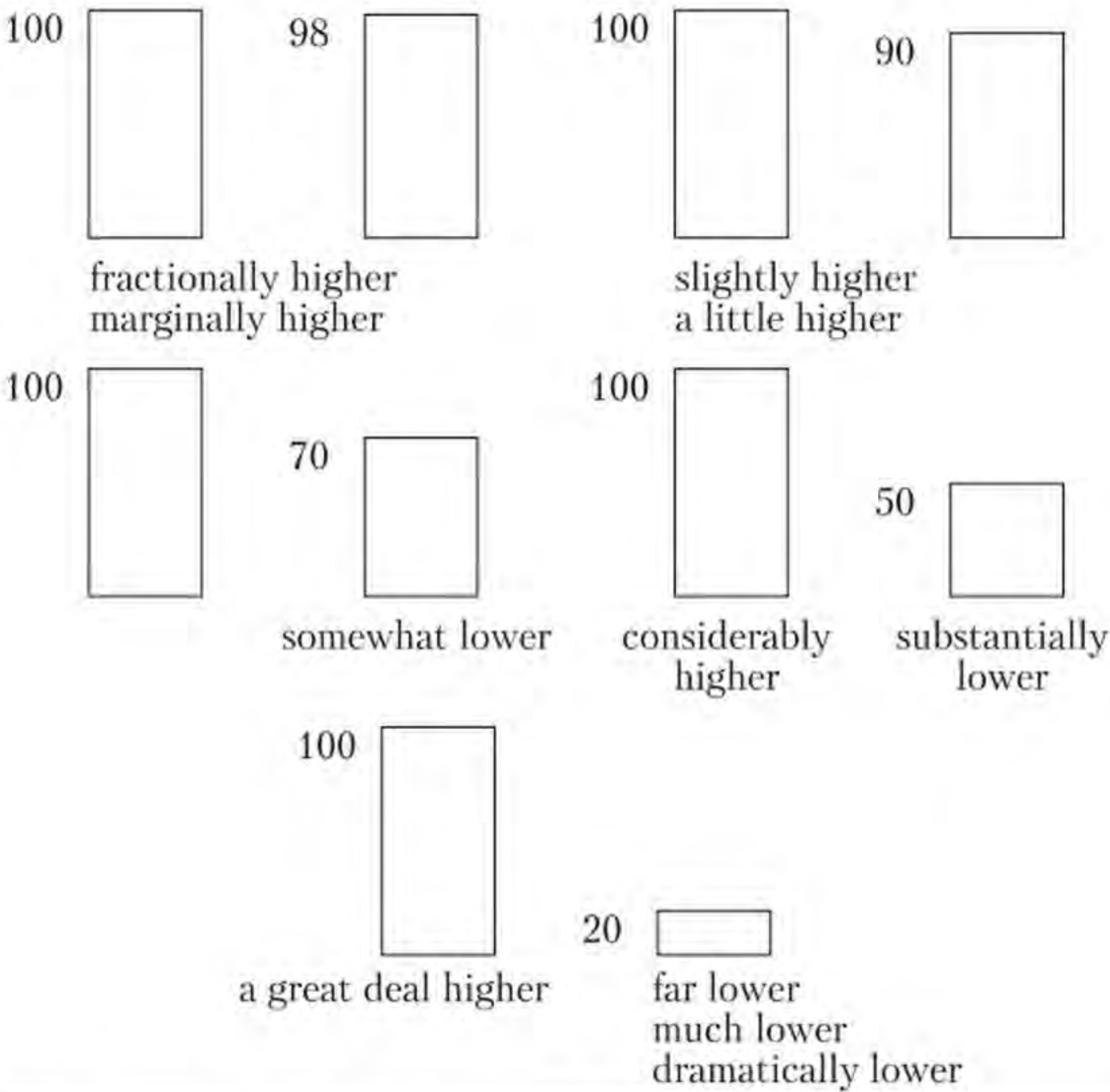
1. Notice some of the most common expressions used to describe trends.

a) To indicate upward movement:		b) To indicate downward movement:	
a rise an increase a climb a jump a growth	to go up to rise to increase to climb to jump to grow	a fall a drop a decline a decrease	to go down to fall to drop to decline to decrease

- c) To indicate stability and fluctuation:

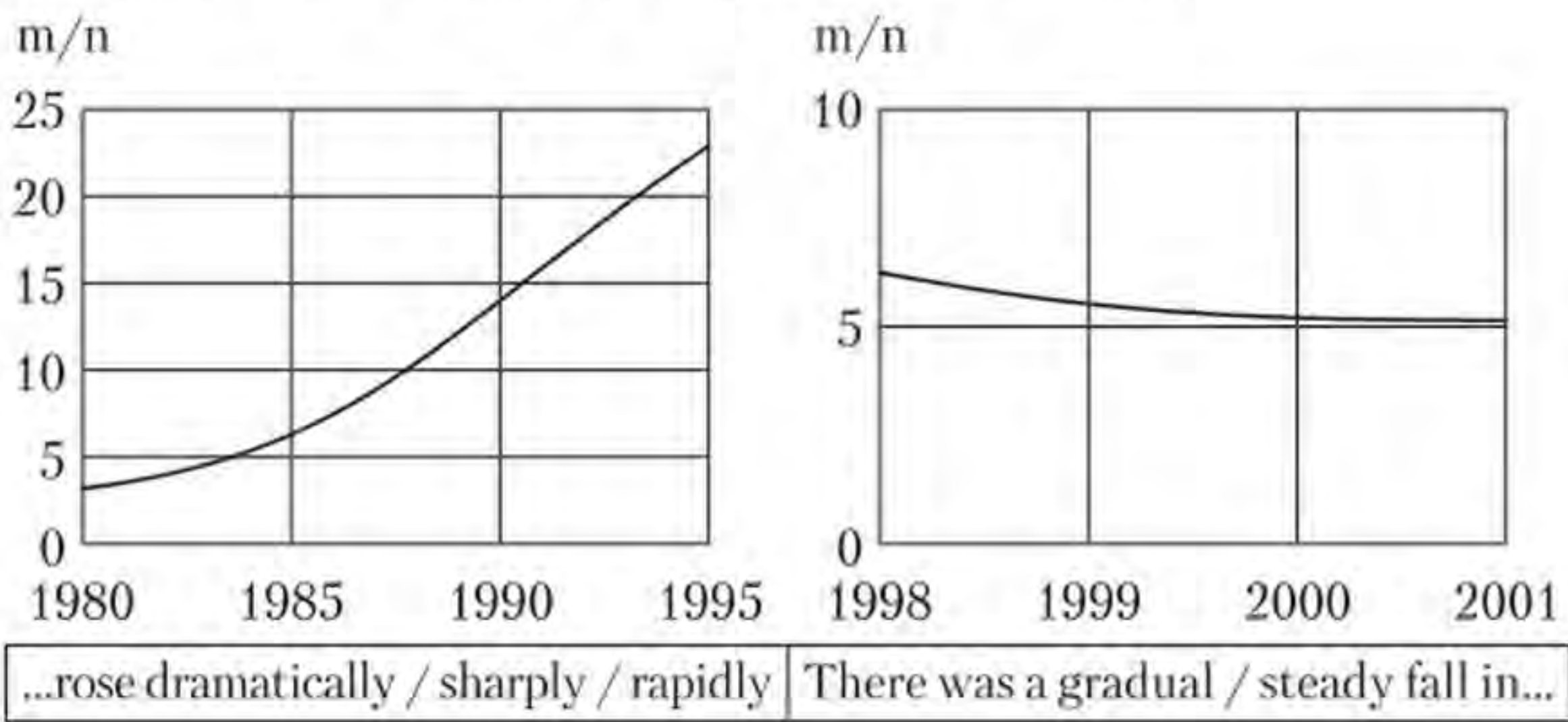


2. Notice the most important intensifiers and softeners which indicate the extent of change.



...were / was slightly lower ...dropped slightly There was a slight drop in...	...was dramatically higher There was a dramatic increase in... ...rose dramatically
--	---

3. Notice how the rate of change can be indicated.



4. Mind the use of prepositions in the context of trends.

The percentage rose *from* 30% *to* 60%.

The figure fell *from* 60% *to* 30%.

The amount stood / stayed *at* 129,000.

The figure rose *by* ten percent.

There was a rise *of* six percent.

5. Now look through the last paragraph of the text about accelerators. Notice what language is used to describe the graph which shows the progress in obtaining high collision energies since 1930.

6. Look at these statements about the graph. Are they true or false?

1) On the left hand vertical axis you see particle energy measured in volts, while the horizontal axis shows time in years from 1930 to 1990.

2) If we take the years in ten year blocks, we can see that, starting from the 1930s, the energy has increased by about a factor of 10.

3) As you can see, over the period 1970 – 1990 there was a sharp rise in the collision energy due to a new technology.

7. Add more details to the description of the graph. Take turns with other students to highlight different points. Choose appropriate language from the box. Group the words and phrases according to the trends they describe.

to climb slightly to decline a little	to get worse to get better
to increase steadily / rapidly / significantly	
to drop markedly to rise dramatically to reach a maximum to stay the same to reach a peak	to stabilise to reach a low point to hit bottom to fluctuate to deteriorate

Development

1. Translate the text at sight.

The cyclotron, invented by Ernest O. Lawrence (1901–1958) in 1930, was the first machine developed to accelerate charged particles to high velocities by causing them to pass repeatedly through the same accelerating region. Its operation depends on

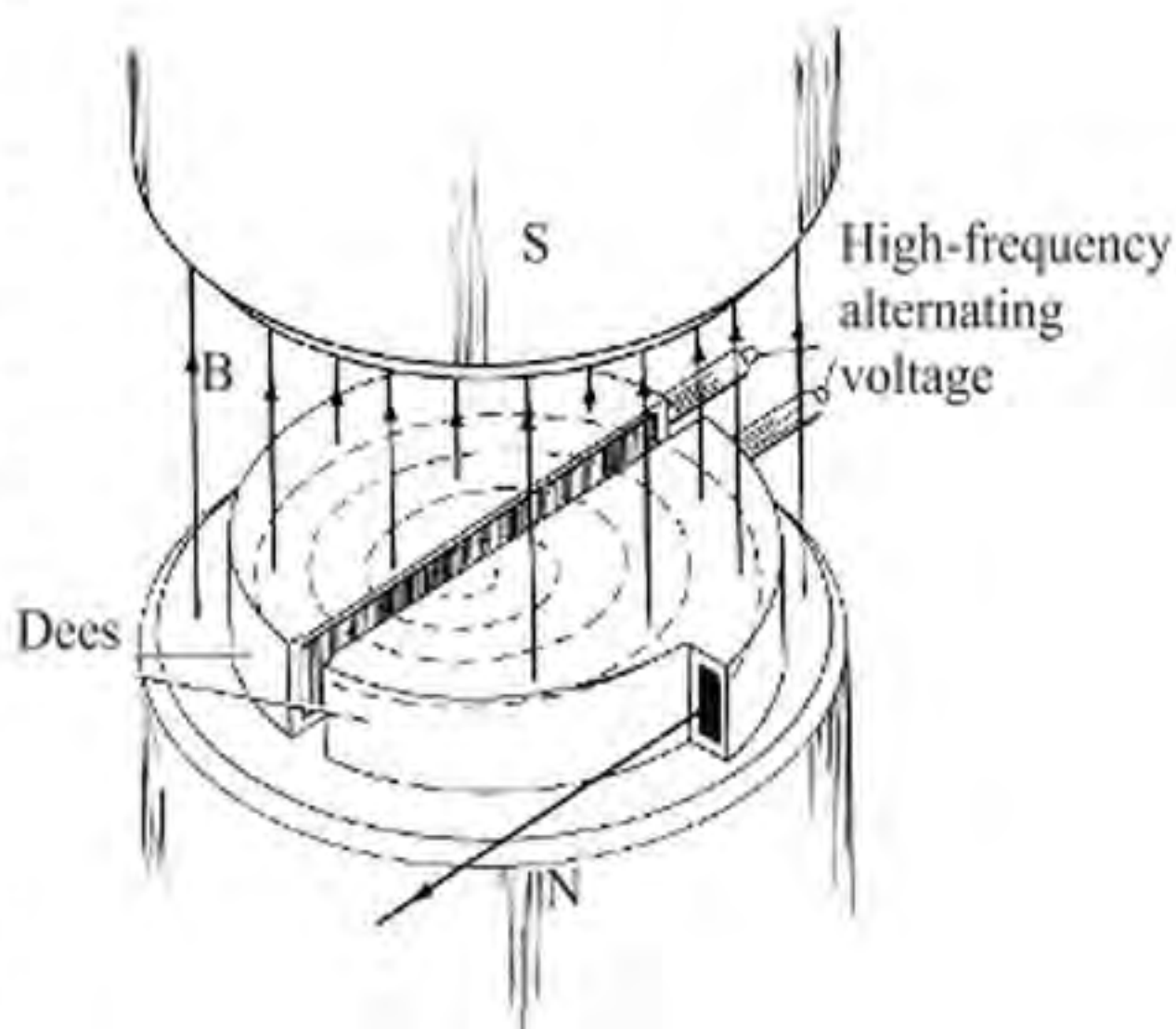
the remarkable fact that the period of the time required for a charged particle to complete one circular orbit in a uniform magnetic field B is independent of the speed of the particle V .

A cyclotron consists of two evacuated hollow metal dees (дуант — D-образное кольцо) in a uniform magnetic field perpendicular to their plane. Protons or other positive ions are injected near the center. An electric generator reverses the potential difference between the dees at the orbital frequency of the ions, so they are accelerated each time they pass through the gap between the dees. This increases their velocity and consequently their orbital radius but does not alter their period.

The operation of the cyclotron depends on the fact that the period is independent of the velocity. However, it is found that the inertial mass of a particle increases rapidly as its velocity approaches the speed of light. This was originally predicted by Einstein's theory of relativity in 1905 and has been well confirmed. This mass increase causes the period to increase and sets a limit to the velocity and kinetic energy attainable with a cyclotron. Higher energies can be achieved in more complex accelerators that gradually vary the magnetic field or the generator frequency as the ions accelerate.

Originally developed for nuclear physics research, cyclotrons have largely been replaced in that area for newer machines. However, they are sometimes used today in hospitals to bombard various targets, including nuclear reactions that produce medically useful radioactive materials.

(from *General Physics*)



The principle of the cyclotron. A magnetic field perpendicular to the plane of the dees maintains the ions in circular orbits. The orbital radius increases as the ions are accelerated by the potential difference between the dees, which reverses at the orbital frequency of the ions.

2. Read the information about DESY, one of the world's leading accelerator centres.

DESY (Deutsches Elektronen-Synchrotron) is one of the most important and renowned institutions on the international research scene. Researchers use the large-scale facilities to explore the microcosm in all its variety — from the interaction of tiny elementary particles and the behavior of new types of nanomaterials to biomolecular processes that are essential to life. The accelerators and detectors that DESY develops and builds are unique research tools. The facilities generate the world most intense X-ray light and accelerate particles to record energies.

a) Match the paragraphs with their titles:

1. Research for the future
2. Speed machines for top performance
3. High tech for highest energies
4. More power plasma waves
5. In search of Higgs & Co

a) To accelerate particles to nearly the speed of light, a sophisticated technology is needed: specially shaped tubes into which powerful radio waves are fed. When electrically charged particles are sent through these resonators, they ride on the radio waves like surfers on ocean waves. In the process, the particles — electrons, for example — are given a boost and accelerated to high energies.

Together with 50 institutes from 12 countries, DESY has been developing a particularly effective accelerator concept — called TESLA technology — since the 1990s. Unlike conventional facilities, the TESLA resonators are superconducting and therefore operate almost without any energy loss: the energy of the electromagnetic fields is transferred almost entirely to the particle beam. However, the resonators function only under extremely cold conditions and are therefore installed in heat-insulated tubes. Inside these tubes, helium cools the temperature to approximately minus 271 degrees Celsius — a superlative refrigerator.

To demonstrate that this technology works and refine it further, the international team built a test facility in Hamburg, which was almost 100 metres long. The joint pilot project was a success. "We managed to unite all the world's experts working on superconducting accelerators into a single team," says DESY

physicist Hans Weise. “Without these partners, it’s doubtful whether we could have developed this sophisticated technology.”

Today, the free-electron laser FLASH is based on TESLA technology; starting in 2015, more than 800 superconducting TESLA resonators will be used in the European XFEL X-ray laser. And research activities are ongoing. The international partners are currently working on making the TESLA resonators even more powerful and cost-effective. The team is also looking for new applications — for example, in facilities that accelerate hydrogen nuclei instead of electrons.

b) Accelerating particles ever more powerfully and efficiently — that’s the goal experts around the world are working toward. To date, they have been setting their hopes on resonators — specially shaped tubes in which powerful radio waves accelerate the particles. The disadvantage of this technology is that it will probably reach its performance limits in the foreseeable future. That’s why researchers at DESY are working together with the University of Hamburg on an alternative concept: plasma accelerators. One day they may boost particles to extremely high energies over a comparatively short distance, thus opening new vistas for research.

This is how a plasma accelerator works: A powerful laser sends a flash of light into a gas, transforming it into a plasma. Next, the laser fires a second, even stronger pulse into this plasma. The second pulse generates a kind of plasma wave that can pull electrons along with it and accelerate them, like surfers riding an ocean wave. This acceleration is considerably greater than what can be generated by present-day facilities.

The concept is still in its infancy, however. So far, plasma acceleration has not functioned reliably enough. Crucial questions remain unanswered — for example, whether and how multiple individual accelerators can be connected in series. To answer these questions, experts from DESY and the University of Hamburg have joined to form the LAOLA team. “Among other things, we want to send the electron bunches from the existing DESY accelerators into the plasma waves so that we can investigate them in detail,” explains Florian Grüner from the University of Hamburg. Experiments like these could one day lead to a new generation of accelerators — facilities that are only a few metres rather than many kilometres long, yet deliver the same performance.

c) Particle accelerators are among the most important tools for research. They speed up tiny, electrically charged particles nearly to the speed of light — that is, to almost 300,000 kilometres per second. A broad range of scientific disciplines benefit from these fast particles. Particle physicists bring them together in head-on collisions to investigate the tiniest building blocks of matter. Chemists, materials scientists and biologists use accelerators to generate the brightest X-ray radiation in the world in order to examine diverse materials ranging from aircraft turbines to microchip semiconductors and proteins that are essential to life. Medical researchers use accelerators for cancer therapy, as the high-energy particle beams can be targeted to destroy tumours.

All accelerators function according to the same principle: powerful radio waves accelerate the particles and massive magnets keep them on course. However, the accelerators' specific technology varies according to the field of application. For the purposes of particle physics, gigantic facilities must endow the particles with as much energy as possible. Only then is it possible to generate and analyse the fundamental components of matter. An accelerator that functions as a light source, on the other hand, must induce the particles to emit extremely brief and intense flashes of X-rays.

The accelerator physicists at DESY are working on both fronts. Together with partners all over the world, they have developed an innovative concept called TESLA technology. This accelerator concept is to serve not only as the basis of a future super-accelerator for particle physics but also as the most powerful X-ray source in the world — the European XFEL X-ray laser in Hamburg. In addition, the experts at DESY are already working on concepts for the future — for example, on a completely new principle that could one day enable them to accelerate particles much more effectively than is possible today.

d) The research carried out at DESY is extremely diverse. The scientists who work here are looking for the tiniest building blocks of matter that make up our world, developing innovative high-tech materials and searching for new mechanisms of action for future medications. As one of Germany's largest research centres, DESY carries out fundamental research that creates new knowledge and new conceptual approaches. This research is the basis on which the challenges of the future can be mastered: issues such as energy supply, climate protection and healthcare require long-term thinking, sustainable solutions and new technologies.

Research at DESY focuses on three areas:

— Accelerators

DESY develops, operates and utilizes state-of-the-art accelerator facilities. Scientists from all over the world use these facilities to investigate the structure and function of matter.

— Photon science

Several of the world's best light sources are located at DESY. Their special X-ray radiation makes atomic structures and reactions in the nanocosmos visible.

— Particle and astroparticle physics

In global cooperations and large teams, DESY scientists investigate the fundamental building blocks and forces of the universe.

e) DESY physicists take part in the most ambitious project of particle physics: the Large Hadron Collider (LHC) at the CERN research centre in Geneva. The gigantic accelerator boosts protons to unprecedented energies and makes them collide head-on with one another. These collisions can give rise to exotic, short-lived particles that reveal what fundamental building blocks the world is made of. Complex detectors as large as office buildings monitor the proceedings.

With its record-setting energy, the LHC is expected to answer some of the most exciting questions in physics, for example: how do elementary particles acquire their mass? According to the physicist Peter Higgs, the cosmos is permeated by a special field that offers the particles due resistance and thereby makes them "heavy". If the theory is correct, there have to be special particles, called Higgs bosons. And indeed, in the summer of 2012, the LHC quite likely detected such a particle.

But the largest scientific machine in the world could also detect entirely different, so far merely speculative phenomena. One fascinating result would be the discovery of SUSY particles, which could also provide an explanation for dark matter.

(http://www.desy.de/about_desy/desy/research_for_the_future/index_eng.html)

b) Discuss the content:

1. Look through paragraph 1 and highlight the main areas of research at DESY.

2. Look through paragraph 2 and point out what scientific disciplines benefit from particle acceleration.

3. Look through paragraph 3 and comment on TESLA technology. Focus on its advantages as compared to conventional facilities.

4. Highlight the principle of work of a plasma accelerator mentioned in paragraph 4. What is expected from a new generation of accelerators?

5. Paragraph 5 considers the Large Hadron Collider. Say what results scientists obtained with the help of the world's most powerful accelerator.

c) **Reproduce the main points about DESY in the form of a “mind map” and use the information as a basis for a summary.**

Active Vocabulary

argue available conclude condition	consider describe determine examination	occur relate research result
---	--	---------------------------------------

1. argue [ˈɑːɡjuː] (*v*) — дискутировать, спорить; доказывать, убеждать; обсуждать; отстаивать; возражать; утверждать, считать; указывать

to ~ about / over smth

спорить о чем-л.

to ~ in favour of / for smth

приводить доводы в пользу чего-л.

to ~ against smth

приводить доводы против чего-л.

To ~ this, it is not sufficient to...

Чтобы утверждать это, недостаточно...

The purpose of this book is to ~ in favour of...

Цель этой книги — привести доводы в пользу...

Section 3 ~s that...

В разделе 3 доказывається, что...

In this paper I will ~ for a model of...

В этой статье я приведу доводы в пользу модели...

It has been ~ed that...

Считается, что...

argument [ˈɑːɡjumənt] (*n*) — довод, аргумент; дискуссия, спор; анализ; рассуждение

conclusive / convincing ~

убедительный довод

strong / valid ~

веский довод

general / important /

обычный / важный /

interesting / logical ~

интересный / логичный довод

detailed ~

подробный анализ

line of ~

последовательность доводов

the essence of an ~

суть аргумента

to present an ~ (to fail) to make a convincing (enough) ~ for... to back up one's ~ with (data)	представлять довод (не)привести (достаточно) убедительный довод в пользу... подкреплять свой довод (данными)
to base one's ~s on to put forward one's (elegant) ~s (to the effect that...)	основывать свои доводы на выдвигать (интересные) доводы (следующего содержания / суть которых...)
to raise an ~ against to have an ~ over / about a matter of ~ to develop an ~	приводить довод против спорить о спорный вопрос излагать довод

argumentation [ˌɑːɡjʊmenˈteɪʃn] (*n*) — обоснование, аргументация
a compelling / valid ~ убедительная аргументация

2. available [əˈveɪləbl̩] (*adj*) — доступный, имеющийся в наличии; пригодный; действительный

easily, readily / widely ~ to smb	легко / широко доступный для кого-л.
~ information / methods / material / source of information / technologies	информация / методы / материал / источник информа- ции / технологии, имеющиеся в наличии
data / evidence already ~ to be / become ~ from measurements	уже имеющиеся данные быть / стать доступным в результате измерений
to make ~ generally ~ knowledge	делать доступным общедоступные знания
the variety of methods ~ for use	многообразие методов, пригод- ных для использования
to be unavailable	не иметься, отсутствовать

availability [əˈveɪləˈbɪləti] (*n*) — наличие; доступность; пригодность

3. conclude [kənˈkluːd] (*v*) — делать вывод; заканчивать; заключать

to ~ an agreement	заключать договор
to ~	в заключение

conclusion [kənˈkluːʒn] (*n*) — вывод; заключение; окончание

a correct / erroneous / firm / grounded / important / main / opposite / preliminary / reason- able / scientific ~	правильный / ошибочный / твердый / обоснованный / важный / главный / противо- положный / предварительный / разумный / научный вывод
--	---

to accept / challenge a ~	признавать / оспаривать вывод
to arrive at / come to / reach a ~ on / concerning smth	приходить к выводу о чем-л.
to draw / make a ~	делать вывод
to jump to ~s	делать поспешные выводы
to draw ~s from observations	делать выводы на основе наблюдений
to bring to a ~	завершать, доводить до конца
to add in ~	добавить в заключение
In conclusion, it may be said that...	В заключение можно сказать, что...

conclusive [kən'klu:sɪv] (*adj*) — убедительный; решающий; окончательный

~ evidence / facts	убедительные факты
There is no ~ evidence (on)...	Нет убедительных доказательств...

4. condition [kən'dɪʃn] (*n*) — условие; положение; состояние; режим; *pl* обстоятельства; условия

additional / different / essential / extreme / general / similar / specific / strict / typical ~s	дополнительные / разные / важные / экстремальные / общие / похожие / особые / строгие / типичные условия
under / in such ~s	при таких условиях
to accept / impose a ~	принимать / накладывать условие
to observe the ~s	соблюдать условия
to meet / satisfy a ~	удовлетворять условию
to violate a ~	нарушать условие
on ~ that	при условии, что
on no ~	ни при каких условиях

conditional [kən'dɪʃnəl] (*adj*) — условный

5. consider [kən'sɪdə] (*v*) — рассматривать; считать, полагать; учитывать

to ~ an effect / a problem / a result / a theory	рассматривать эффект / задачу / результат / теорию
---	--

considerable (*adj*) — значительный, большой, важный

a ~ amount of evidence / work	большое количество данных / работы
to a ~ degree	в значительной степени
a ~ body of facts / data / information	значительное количество фактов / данных / сведений
a ~ confusion / difference	большая путаница / разница
Of ~ interest here is...	Значительный интерес представляет...
~ developments	важные события

to need ~ skill / experience	требовать большого мастерства / опыта
to have a ~ impact on	оказывать большое влияние / воздействие на

considerably (*adv*) — значительно, гораздо

to be ~ different	значительно отличаться
to increase / decrease / change / differ ~	значительно увеличиваться / уменьшаться / изменяться / отличаться

consideration (*n*) — рассмотрение; соображение; внимание

to take into ~	принимать во внимание
to leave out of ~	упускать из виду, не принимать во внимание
under ~	рассматриваемый
on no ~	ни при каких условиях
Consideration is being given to...	Рассматривается...

6. describe [dɪ'skraɪb] (*v*) — описать (описывать)

to ~ accurately / thoroughly	описывать точно / подробно
to ~ novel phenomena	описывать новые явления
to ~ smth in terms of	описывать что-л. в виде / в понятиях
a way to ~ / of ~ing	способ описания
to ~ in detail	описывать подробно

description [dɪ'skrɪpʃn] (*n*) — описание

an (in)accurate / formal / schematic / scientific / simplified ~	(не)точное / формальное / схематическое / научное / упрощенное описание
--	---

7. determine [dɪ'tɜːmɪn] (*v*) — определять; решать

to ~ carefully / previously	определять тщательно / ранее
to ~ the amount / degree (of)	определять количество / степень
to ~ a class / constant / direction / relationship	определять класс / константу / направление / отношение
It is difficult to ~ whether...	Трудно определить...
Calculations have been made to ~ ...	Вычисления проведены, чтобы определить...
We aim to ~ whether...	Наша цель — определить...

8. examination [ɪgˌzæmɪ'neɪʃn] (*n*) — исследование; изучение; внимательное рассмотрение

a detailed / careful, thorough, close / complete ~ (of the material / data)	подробное / тщательное / полное изучение / исследование (материала, данных)
to be under ~	рассматриваться, исследоваться, изучаться

Under close ~ ...

the problem under ~

to do / make an ~

to require an ~

to base one's hypothesis on an ~
(of)

the reexamination of basic
assumptions

Examination of... reveals / points
to / suggests that...

При внимательном рассмотре-
нии...

рассматриваемая проблема

проводить исследование

требовать внимательного рас-
смотрения

основывать гипотезу на исследо-
вании

пересмотр основных
предположений

Исследование... выявляет / ука-
зывает на / предполагает, что...

examine [ɪgˈzæmɪn] (v) — исследовать, обследовать; прове-
рять; рассматривать

to ~ in detail / carefully, closely,
thoroughly

to ~ a case /
problem / system /
theory

to ~ smth in connection with
the objective of ~ing

In the period ~ed, ...

It is important to ~ ...

In this subsection I shall ~ ...

исследовать подробно / тща-
тельно

исследовать (рассматривать)
случай / проблему / систему /
теорию

исследовать что-л. в связи с
целью изучения

В исследуемый период...

Важно проверить...

В этом подразделе я рассмотрю...

9. occur [əˈkɜː] (v) — происходить, случаться, иметь место;
встречаться; наблюдаться; присутствовать, входить (в урав-
нение)

to ~ frequently / naturally /
regularly / rarely

to explain why a given phenome-
non ~s

to ~ under certain conditions

Arguments / changes ~
when...

происходить часто / в природе /
регулярно / редко

объяснить, почему происходит
данное явление

происходить при определенных
условиях

Споры / изменения имеют место,
когда...

occurrence [əˈklɪrəns] (n) — событие; случай; проявление; су-
ществование, наличие, присутствие; распространение

common / regular ~

of common / rare ~

of natural ~

natural ~

frequency of ~

an ~ of a variable in a formula

to rule out an ~

обычное / регулярное проявление

обычно / редко встречающийся
природный

распространение в природе

частота проявления

наличие переменной в формуле

исключить случай

10. relate [rɪˈleɪt] (v) — относить(ся); связывать; касаться

to clearly / closely / (only) distantly ~ to smth
~ed elements / fields / aspects

a principle / phenomenon / process ~ing to smth
interrelating fields of study

to correlate [ˈkɒrɪleɪt] data with structural features
to be inversely ~ed

These effects are ~ed to...
Closely ~ed to it is the problem of...

быть явно / тесно / (только) отдаленно связанным с чем-л.
связанные элементы / области / аспекты
принцип / явление / процесс, касающийся чего-л.
взаимосвязанные области исследования

соотносить данные со структурными особенностями
быть обратно пропорционально связанными

Эти эффекты связаны с...
С этим тесно связана проблема...

relation [rɪˈleɪʃn] (n) — отношение, соотношение; связь, зависимость; закономерность

a basic / characteristic / derived / general / special ~

implicit ~
linear ~
to demonstrate / discover / reveal a ~
to account for a ~
to establish / set up a ~ with / in ~ to
~s that exist within / depend on / hold

to bear a ~ to / to bear no ~ to

основное / характеристическое / производное / общее / частное соотношение

неявная функция
линейная зависимость
выявлять / обнаруживать / раскрывать отношение (связь)
объяснять отношение (связь)
устанавливать отношение (связь)
относительно чего-л.

отношения, которые существуют в / зависят от / имеют силу
иметь отношение к / не иметь никакого отношения к

relationship [rɪˈleɪʃnʃɪp] (n) — отношение, взаимосвязь, связь; соотношение, зависимость

a complex / direct / important / mathematical / simple ~

a one to one ~
a phase ~
linear ~
a ~ between variables / stages

a ~ between temperature and pressure

сложное / прямое / важное / математическое / простое отношение (соотношение)

взаимно однозначное соответствие
правило фаз
линейная зависимость
взаимосвязь между переменными / стадиями

отношение температуры к давлению

to determine / discover /
focus on /
illustrate a ~

to shed light on a ~
to participate in a ~
to be concerned with a ~
to present a ~

определять / обнаруживать /
сосредотачивать внимание на /
пояснять соотношение (взаимо-
связь)

проливать свет на соотношение
участвовать во взаимосвязи
заниматься соотношением
показывать соотношение

relative [ˈrelatɪv] (*adj*) — относительный

a ~ importance /
significance / value / merit
a ~ lack of interest in

~ to

относительная (-ое) важность / зна-
чение / ценность / достоинство
относительный недостаток инте-
реса к

относительно, по отношению к

relatively (*adv*) — относительно

~ firm / high / limited / low /
recent / short / simple / small

a ~ new discipline
a ~ optimistic view
to start with what is ~ well known
and clear cut
to make use of ~ recent develop-
ments
It is ~ simple to verify that...

It is a ~ simple matter to...

относительно твердый / высокий /
ограниченный / низкий / новый /
короткий / простой / маленький

относительно новая дисциплина
довольно оптимистичный взгляд
начать с того, что довольно
хорошо известно и ясно
использовать относительно
недавние достижения
Сравнительно просто проверить,
что...

Довольно легко...

relativity [ˌreləˈtɪvətɪ] (*n*) — относительность; принцип отно-
сительности

Einstein's ~ theory

теория относительности Эйн-
штейна

relativistic [ˌrelatɪˈvɪstɪk] (*adj*) — релятивистский

11. research [rɪˈsɜ:tʃ] (*v*) — исследовать

research (*n*) — исследование; поиск

pioneer / basic ~

~ on the development (of)
~ and development
a ~ assistant / worker
a ~ project / program

a ~ team
to be engaged in ~

новаторское / проблемное иссле-
дование

исследование роста / развития
научно-исследовательская работа
научный сотрудник / работник
научно-исследовательский (-ая)
проект / программа

исследовательская группа
заниматься научно-исследова-
тельской работой

to carry out / conduct / do / pursue ~	проводить (осуществлять) исследование
to attempt / undertake ~ in/ into smth	предпринимать исследование чего-л.
the field / scope of ~	область исследования
the state of ~	состояние исследования
in this line of ~	в этой области исследования
This research seeks to determine... / revealed... / provides much insight into the problem / will yield revolutionary data.	В исследовании ставится цель определить... / выявлено... / дается хорошее представление о проблеме / будут представлены принципиально новые данные.

researcher [rɪˈsɜ:tʃə] (*n*) — исследователь

a ~ in	исследователь в области чего-л.
~s at Lawrence Laboratory	исследователи в лаборатории Лоренца
challenges facing ~s	задачи, стоящие перед исследователями
data compiled by ~s	материалы, собранные исследователями
questions important to the ~s	важные для исследователей вопросы

12. result [rɪˈzʌlt] (*v*) — происходить, следовать, получаться

to ~ in	приводить к, выражаться в, иметь результатом, заканчиваться чем-л.
to ~ from differences / lack of knowledge / incorrect use	являться результатом различий / недостатка знаний / неправильного использования

result (*n*) — результат

a convincing / definite / dramatic / final / good / important / intermediate / plausible / positive / preliminary / previous / recent / reliable / striking / unexpected / useful / valid / well established ~	убедительный / определенный / значительный / окончательный / хороший / важный / промежуточный / правдоподобный / положительный / предварительный / предыдущий / последний / надежный / поразительный / неожиданный / эффективный / достоверный / хорошо установленный результат
as a ~ of an effort	в результате усилия
~s relevant to	результаты, относящиеся к чему-л.
to apply a ~	применять результат

to confirm / describe / formulate / interpret / obtain / present / yield ~s	подтверждать / описывать / формулировать / интерпрети- ровать / получать / представ- лять / давать результаты
to analyze / summarize the ~s of a study / research	изучать / обобщать результаты исследования
to collect all ~s in a paper with the ~ that as a ~ (of)	собирать все результаты в статье с тем результатом, что в результате (чего-л.)

resulting (*adj*) — полученный, получающийся; соответствующий; окончательный

the ~ value

полученное значение

Vocabulary Work

1. Consulting the Active Vocabulary. Combine adjectives with nouns.

convincing
close
remarkable
conclusive
available
considerable
accurate
significant
strong
thorough
general
regular
dramatic

law
argument
data
description
difference
examination
result

2. Check whether you know the following English word combinations from the Active Vocabulary.

to argue in favour of the validity of a theory, to back up one's arguments with data, a matter of argument, evidence already available, models available for use, to draw a conclusion, to violate a condition, a considerable body of facts, all things considered, to leave out of consideration, to describe smth in terms of, a simplified description, to determine the degree of, under close examination, to examine thoroughly, to occur under certain conditions, to rule out an occurrence, the state of research, to be engaged in research, challenges facing researchers, related aspects, to be in special relation to, a relative merit, to make use

of relatively recent developments, with the result that, preliminary results, to yield results

3. Give the English equivalents for the following word combinations.

приводить доводы против, суть аргумента, привести убедительный довод в пользу, имеющийся источник информации, оспаривать вывод, ни при каких условиях, рассматривать подробно, важные события, оказывать большое воздействие на, принимать во внимание, описывать что-либо в виде, определить количество чего-либо, часто случаться, частота проявления, проводить исследование, исследовательский проект, область исследования, быть обратно пропорционально связанным, относительно чего-либо, взаимосвязь между, относительный недостаток интереса к, использовать относительно недавние достижения, являться результатом различий, применять результат

4. Translate the following sentences from English into Russian.

1. The purpose of this article is *to argue in favour of* the validity of the theory in question. There is a serious *argument* against this approach. This phenomenon still remains a subject of much theoretical *argument*. This *argument* seems to make no sense.

2. Such computers are widely *available* now. Only this part is *available* for direct chemical analysis. *Availability* of precise instruments makes it easier to carry on the work. As more data became *available*, the results obtained in the previous years were confirmed. The *availability* of new techniques increases.

3. He *concluded* the chapter with a few observations on the origin and nature of the phenomenon. The *concluding* section of the monograph is devoted to the data analysis. Further research is required before firm *conclusions* can be drawn concerning the mechanism of the reaction. When writing a scientific paper, state your *conclusions* as clearly as possible. In *conclusion*, the present study supports our point of view.

4. Game theory, a theory of rational decision making under *conditions* of uncertainty, was first developed by J. von Neumann. To obtain hints of how the cosmos evolved cosmologists solve equations that represent *conditions* during the earliest moments of the universe. In the above relation both *conditions*

are violated. Astronomical masers form only under certain **conditions** of pressure, temperature and gas velocity.

5. Some imagination is needed when we **consider** such a complicated problem. **Consideration** of the new results will require a careful comparison with the available data. In this review we have discussed in **considerable** detail developments that took place during the last five years. These findings may be of **considerable** practical value. In the past decades the number of scientific publications has **considerably** increased. In this chapter detailed **consideration** is given to the main investigations in adjacent areas.

6. The problem is too complicated to be **described** in a few words. Classical physics is not adequate to **describe** these phenomena. Within the accuracy of the data **described** these rules are rather well satisfied. Such a **description** is not in accordance with the known facts.

7. When a nucleus at rest emits one particle, energy and momentum conservation **determine** its energy. The corresponding magnetic dipole moment **determines** how an electron interacts with an applied magnetic field. This constant is **determined** from the spectrum of hydrogen.

8. In this work we confined ourselves to **examining** the behaviour of one type of particles. A careful **examination** of the discrepancies between the predicted and experimental values is required. Limitations of this method will be closely **examined** in the next subsection. In the period **examined**, physicists have made good use of this theory. We conclude with an **examination** of nuclear decay process.

9. The core of the problem is to find out whether this process **occurs** regularly. The above work bears essentially on nuclear reactions **occurring** on various celestial bodies. This is a very weak effect since the coordinated motion of the ions is not a frequent **occurrence**. However, when these interactions were first studied, it was still unclear why superconductivity **occurs**. These measurements can be used to study the processes that **occur**.

10. Table 1 attempts to assess the **relative** significance of these phenomena. A **relatively** optimistic analysis comes from US researchers. Further interesting information **relative to (relating to)** the equation of state may be found in Ref. 24. He was led to this idea by considering the **relationships** between the basic laws of electromagnetism.

11. My lecture is an attempt to review briefly some of the latest **research** data in this area. The aim of this **research** is to obtain sufficient information about this phenomenon. It is important to have access to recent publications in this field of **research**. We still do not have a clear picture of our future **research**. Most nuclear physics **research** has been done with these energies.

12. Caution must be exercised when interpreting these **results**. Progress in science depends on independent confirmation of research **results**. The factors underlying these **results** remain unclear. Preliminary **results** of this investigation have been communicated to a conference. The **results** reveal agreement between the experimental and computed values.

5. Translate into English using the Active Vocabulary.

1. Большинство (majority) участников конференции высказались против предложенного нами метода. Целью книги является доказать достоверность этой теории. Вы предлагаете убедительные доводы в пользу этой концепции. Аналогичный аргумент подходит для всех случаев. Этот довод основывается на проверенных фактах.

2. Методы, ставшие недавно доступными для проведения данного исследования, способствовали получению надежных (reliable) результатов. К сожалению, такие материалы не были доступны для анализа в течение долгого времени. Имеются несколько подходов к решению рассматриваемой проблемы. Нет никакой информации об этом явлении.

3. На основании этих данных мы пришли к выводу, что первоначальная идея была ошибочной. Приняв все во внимание, мы пришли к выводу, что процесс в общей сложности занимает около 10 минут. К сожалению, нам не удалось завершить работу. Не следует делать поспешных выводов, давая оценку результатам исследования. Данное исследование, как предполагают, позволит получить убедительные результаты.

4. Условия для протекания процесса оказались довольно благоприятными. Во время эксперимента соблюдались условия, необходимые для образования ионов. Мы изучаем оптические явления, происходящие в кристаллах при определенных экспериментальных условиях. В этих условиях использование вышеупомянутого метода представляется нецелесообразным (impractical).

5. Эксперименты дали (provide) значительное количество сведений об этом явлении. Ваш вопрос будет подробно рассмотрен на следующем семинаре. Рассмотрим следующую группу уравнений. Этот процесс значительно отличается от того, который мы наблюдали ранее.

6. В статье описывается методика эксперимента (experimental procedure). В описании этого явления не хватает точности. Была введена (introduce) терминология для описания этого механизма.

7. Мы провели серию экспериментов с целью определения области контакта. Трудно определить, насколько (to what extent) эти явления взаимосвязаны. Следующие несколько лет позволят определить направление, в котором эта область физики будет развиваться (head in).

8. После тщательного изучения фактов обнаружилось, что теория неверна. В рассматриваемый период была проведена большая исследовательская работа. При внимательном рассмотрении видно, что эти два процесса имеют много общих характеристик. Здесь мы рассматриваем механизм взаимодействия частиц при определенных условиях.

9. Следует принять меры (take measures), когда произойдет утечка (leak). Этот процесс будет иметь место при любом давлении. При определенных условиях происходит резкое (drastic / sharp) увеличение тепла (increase in heat). Они попытались исключить (exclude) проявление таких факторов. Недавно ученые зарегистрировали (record) случай землетрясения (earthquake) в этом районе.

10. Естественно начать с того, что относительно хорошо известно и ясно. Мы не знаем, как эти свойства связаны друг с другом. Энергия и длина волны (wavelength) связаны обратной зависимостью. Интересную информацию относительно этого явления можно найти в следующей главе (chapter). Достигнута (attain) относительно высокая точность (accuracy) измерений.

11. Существуют расхождения (discrepancy) между результатами, полученными различными исследователями. Целью исследования является получение данных, подтверждающих правильность наших выводов. Недавние исследования природы этого явления подтвердили нашу гипотезу. Фундаментальные исследования структуры материи были очень важными. Мы предприняли это исследование для того, чтобы получить экспериментальное подтверждение достоверности теории.

12. Недавно полученные результаты согласуются (be in accordance with) с предыдущими исследованиями. Взрыв такой силы может привести к непрогнозируемым (unpredictable) последствиям. В результате это открытие было надолго забыто. Этот проект является результатом совместных усилий специалистов, работающих в разных областях науки и техники.

Grammar Focus

Modal Verbs

1. Check whether you can answer the following questions about modal verbs.

What modals from the box are used

- a) to express strong obligation that involves the speaker's opinion?
- b) to express a general obligation based on a law or rule, or on external authority?
- c) to express mild obligation, or advice?
- d) to express permission?
- e) to express an obligation of a preplanned character, or mutual arrangement?
- f) to express an obligation arising out of circumstances?
- g) to express requests?
- h) to express willingness?
- i) to express offers?
- j) to express necessity?
- k) to express prohibition?
- l) to express characteristic behaviour or qualities of things?
- m) to show possibility?
- n) to express ability?
- o) to express intention, decision, or an offer made at the moment of speaking?
- p) to make suggestions?
- q) to express commands in public notices or documents?
- r) for instructions?

must	may	will
have to	might	shall
be to	can	be able to
should	could	be allowed to
ought to	would	need

2. Read the extract below. Find the modals and comment on their use.

...To become a physicist or astronomer and really participate in scientific progress, one has to master the entire body of knowledge in the field one has chosen. Dilettantism has no place here. Science today is incredibly complex and its mathematical equipment is so abstract and abstruse that the non-initiated simply could not fathom the degree of complexity of the whole. Actual work in science demands that you become an expert in applying mathematical tools. Your knowledge of contemporary mathematics and related fields must be profound. This is the only level of expertise that allows one to reach the essence of subjects studied in physics and astronomy.

[,dɪlə'tæntɪzəm]

abstruse — трудный
для понимания
fathom ['fæðəm] —
постигать

expertise [,ekspɜ:'tɪz] —
знания и опыт

For a number of reasons, this level is not open to just anyone wishing to climb to it. Only a few become physicists, quite a few only handle mathematics within a high school course. Does it mean that any opportunity to admire the awesome achievements of physics is forever closed for these people, that it is impossible to find out about the science which penetrates the mystery of how matter is structured at its deepest levels and at the same time discovers the quanta of time and space?

awesome — внуша-
ющий благоговение

penetrate — прони-
кать в/на

Of course it does not, and one can describe the achievements of physics clearly and correctly to anyone interested, even without resorting to arithmetic. It means, however, that one should not try to explain all the details and difficulties in calculations and all the logical relations that lead to drawing the conclusions. The strategy must be different: one must try to create a shining image of a phenomenon, to make the reader form an idea of

resort to — прибе-
гать к

what the physicists attempt to achieve. These images can be understood without mathematics and can be admired and applauded. Remember, however, that if you are not a professional, not a physicist, do not entertain the illusion that having read a popular book you may be able to offer a “hypothesis” that would solve the difficulties outlined in the book. Nothing good will come of it. An image is definitely not “her majesty physics”. To offer a useful hypothesis, one has to become professional; however, everyone can enjoy an image drawn by a professional.

entertain — зѡ. пи-
татъ, лелеатъ

By way of comparison, I can say that I love music passionately but that God did not grant me a musical ear. I will never write music, nor reproduce even an elementary tune. I do enjoy listening to music written by (talented) professionals and performed by equally professional (also talented) individuals, and will continue to do so.

People who cannot draw or paint at all, do enjoy paintings, those who could not write a novel enjoy reading novels.

It is my firm belief that a similar situation holds for attempts to make science understood by the non-scientist. The author’s goal must be to create a strong, impressive image.

(from *The River of Time*)

3. Study the table. Pay attention to how modal verbs are used in order to express degrees of probability about the present and the past.

The scale of probability

<i>Present / Future (with Indefinite Infinitive)</i>			
must	должно быть	probability, or near-certainty (based on evidence)	There must be an explanation for this fact.
should	наверное, по всей вероятности		Должно быть, существует какое-то объяснение этому факту.

<i>Present / Future (with Indefinite Infinitive)</i>			
may	вероятно	possibility (often based on specula- tion)	This problem <i>may be</i> of particular interest to you. Эта проблема, вероятно, представит для вас особый интерес. The approach <i>could (might)</i> <i>be</i> quite useful in this case. Возможно, данный метод будет довольно эффекти- вен в этом случае.
might	возможно, может быть		
could			

<i>Past (with Perfect Infinitive)</i>			
must	должно быть	They must have made the wrong assumption. Должно быть, они сделали неправильное предположение.	The machine was broken yesterday but the operator should have repaired it by now. Устройство сломалось, но сейчас оператор, наверное, его уже починил.
should	наверное		
may	вероятно		
might	возможно	They may have overlooked an error in the calculations. Вероятно, они не заметили ошибку в расчетах.	He could (might) have changed the procedure. Он, возможно, изменил методику.
could			

<i>Negative</i>			
can't	не может быть	The value can't / couldn't be positive. Не может быть, чтобы значение было положительным. The meeting can't / couldn't have been postponed. Не может быть, чтобы совещание перенесли.	He may / might not have taken the readings yet. Возможно, он еще не снял показания.
couldn't			
may not	возможно	He may / might not have taken the readings yet. Возможно, он еще не снял показания.	
mightn't			

4. Look at the following sentences and identify those which express degrees of likelihood. Translate the sentences into Russian.

1. The reaction **could not** proceed under such conditions.
2. He **can't** still be in the laboratory, it's after 8 o'clock.
3. The results **should** be checked, we **can't** take them for granted.
4. They **ought** to pay more attention to the problem.
5. This view **can't** have been accepted.

6. They **should** have no trouble doing the experiment, the equipment has been checked thoroughly.
7. We **might** change the subject matter in case new ideas turn up.
8. He looks so unhappy, he **must** be having trouble at the moment.
9. No matter what happens you **may** rely on our help.
10. They **must** have made some corrections in the programme.
11. He has worked hard on the problem for a long time and **can** make a report on the progress achieved at our weekly seminar.
12. You **may** leave the laboratory before the end of the experiment only if you have a special permission.
13. He **may** have failed to find experimental evidence for the existence of this particle.
14. You **must** be very careful performing this dangerous experiment.

5. Try to group the identified sentences according to whether they express probability or possibility.

6. Categorise the remaining sentences under the headings "obligation" (mild or strong), "permission", and "ability".

7. Suggesting possible cause and result.

Introduce "may / might / could" in statements of possible result. Study the following situations and say what may, might or could happen if an action is either carried out or not carried out. Use the pattern.

Example: *A cylinder of gas is standing near a source of heat. It is possible that it will explode unless it is removed.
If the cylinder is not removed, the gas **may** / **might** / **could** explode.*

1. An unknown substance is very near some acid. It is possible that it will react if it comes in contact with the acid.
If the substance is not removed, it...
2. A transistor is being connected in a circuit. However, the connections are wrong, and it is possible that the transistor will be ruined unless the connections are altered.
If the connections aren't altered, the transistor...
3. A material is being heated. It is possible that it will burn if the temperature is raised any more.
If the temperature is raised any more...
4. A material is being stretched. It is possible that it will undergo permanent deformation unless the force is removed soon.
If the force is not removed soon...

5. A plastic container is very near a source of heat. It is possible that it will melt if it remains there.
If the plastic container isn't moved away from the source of heat...
6. A cylinder contains a gas under pressure. However, there is a small crack in the cylinder, and it is possible that the gas will escape unless the crack is sealed.
If the crack...
7. A glass bottle is near the edge of a shelf. It is so near the edge that it is possible that it will fall unless it is moved.
If the glass bottle...
8. A container holds a quantity of liquid. If the liquid is left in the container, it is possible that it will solidify, although this is not desirable.
If the liquid...

8. Suggesting possible reason. Introduce “may / might / could” in statements of possible reason.

The battery The switch The wires The lamp The connections	may might could	be	weak (flat) faulty broken damaged wrong
---	-----------------------	----	---

or

It	may might	be	due to because of because	a flat battery a faulty switch a broken wire a wrong connection a damaged lamp the battery is flat the switch is faulty a wire is broken a connection is wrong the lamp is damaged
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9. Showing the possibility or the risk (or danger) of what might happen in various situations.

Make statements from the notes as in the example.

Examples: *substance heated — possibility of explosion*

*The substance must not be heated, otherwise it **may / might / could** explode.*

- 1) material exposed to water — possibility of corrosion
- 2) transistor wrongly connected — risk of damage
- 3) high current passed through wire — risk of overheating

- 4) liquid cooled too quickly — possibility of solidifying
- 5) plastic too near a source of light — danger of melting
- 6) gas exposed to a naked flame — risk of burning
- 7) container damaged — danger of gas escaping
- 8) material stretched — possibility of undergoing permanent deformation

Gerund

1. Study the table with the forms of the Gerund.

	<i>Active</i>	<i>Passive</i>
<i>Indefinite</i>	solving	being solved
<i>Perfect</i>	having solved	having been solved

2. Review the functions of the Gerund.

1. subject <i>Measuring resistance</i> is necessary in this kind of experiments.	Измерение сопротивления необходимо в экспериментах такого рода.
2. predicative Our objective is <i>collecting data</i> .	Наша задача — сбор данных.
3. object It's no use <i>discussing this phenomenon</i> . Scientists succeeded in <i>controlling such processes</i> .	Бесполезно обсуждать это явление. Ученым удалось добиться контроля над такими процессами.
4. adjective There is no reason for <i>doubting the results of the experiment</i> . Don't lose the chance of <i>taking part in this conference</i> .	Нет оснований сомневаться в результатах эксперимента. Не упускайте шанс принять участие в этой конференции.
5. adverbial modifier <i>In considering the problem</i> they came to an interesting conclusion. <i>On obtaining the data</i> they proceeded with the equipment. You should check the equipment <i>before making measurements</i> . <i>By simplifying the procedure</i> you will achieve better results. He described the process <i>without going into detail</i> .	Рассматривая проблему, они пришли к интересному выводу. Получив данные, они продолжили эксперимент. Вам следует проверить оборудование, прежде чем проводить измерения. Упрощая ход эксперимента, вы достигните лучших результатов. Он описал процесс, не останавливаясь на деталях.

Memorise the verbs with prepositions, phrasal verbs, word combinations and phrases preceding the Gerund.

account for	— объяснять
aim at	— стремиться, ставить целью
arise from	— возникать из
be alike in	— быть похожим по (каким-л. свойствам)
be capable of	— быть способным
depend on (upon)	— зависеть от, полагаться на
differ in	— отличаться по (каким-л. свойствам)
give up	— бросать, отказываться
go on	— продолжать
insist on (upon)	— настаивать на
be interested in	— интересоваться
keep on	— продолжать
keep from	— удерживать от, воздерживаться от
be good at	— преуспевать в
object to	— возражать
prevent from	— мешать, препятствовать
rely on (upon)	— полагаться на
be responsible for	— объяснять, являться причиной, обуславливать
result from	— являться результатом
result in	— приводить к, давать в результате
be similar in	— быть похожим по (каким-л. свойствам)
succeed in	— удаваться, добиваться успеха
think of	— думать о
(I) cannot help	— (я) не могу не
it is worth	— стоит (сделать что-л.)
it is no good	— не стоит, бесполезно
it is no use	— не стоит, бесполезно

**3. Match the beginning of each sentence with its logical ending.
There may be more than one variant.**

1. One of the major difficulties lies in...
2. Our approach consists in...
3. Many scientists have contributed to...
4. Some scientists insisted on...
5. We object to...
6. They are engaged in...
7. In my report I will restrict myself to...
8. Scientific conferences help in...
9. In this work we confined ourselves to...
10. Some of our failures result from...
11. The experiment is aimed at...

- a) maintaining the same conditions throughout the experiment.
- b) disclosing the mechanism of the genetic code.

- c) minimizing experimental errors.
- d) attributing too much importance to this factor.
- e) including this question in the conference agenda.
- f) sorting out and classifying the data.
- g) considering the primary effect.
- h) establishing a correlation between the two mechanisms.
- i) underestimating the importance of theory in research.
- j) exchanging knowledge and information.
- k) examining one type of reactions.

4. Study the context in which the Gerund is used and translate the sentences into Russian.

1. Astronomer Edwin Hubble discovered the expansion of the universe by observing that other galaxies are moving away from ours.

2. In addition to being awarded the 1922 Nobel Prize in Physics, Bohr was nominated twice for the Nobel Prize in Chemistry, first in 1920 and subsequently in 1929.

3. In electron spectroscopy information is obtained by analysing the energy spectrum of electrons.

4. Solving the mystery of cosmic acceleration will reveal the destiny of our universe.

5. The possibility of manipulating individual atoms has many applications in chemistry, electronics, engineering, materials science, molecular biology, medicine, and computer technology.

6. Bose–Einstein condensation is of fundamental importance in explaining the phenomenon of superfluidity.

7. Finding asteroids became a popular activity in the 1800s and by the end of the century about a thousand were known.

8. We are still a long way from knowing the answers to questions about the emergence of extraterrestrial life.

9. The ancient Greeks were great philosophers and good at mapping the motions of stars and planets.

10. It is worth further studying to examine where and why these predictions fail.

Types of sentences

The simple sentence ***(простое предложение)***

Simple sentences are used mainly to introduce a new idea, or to emphasise a point. They are less common in writing than in speech.

The compound sentence (*сложносочиненное предложение*)

A compound sentence is two or more simple sentences joined together with coordinating conjunctions like **and, but, either ... or, neither ... nor**.

e.g. Many attempts were made to solve the problem, but all of them failed.

Compound sentences are more common in speech than in writing.

The complex sentence (*сложноподчиненное предложение*)

A complex sentence contains **a main clause** (главное предложение) and one or more **subordinate clauses** (придаточные предложения).

Complex sentences allow the writer to indicate a variety of relationships between ideas.

1. Study the chart with the types of the complex sentence.

<i>Types of clauses</i>	<i>Conjunctions and connectives</i>	<i>Examples</i>
Subject (подлежащие)	<i>that, if, whether, who, what, which</i>	<i>That this formula is only approximately correct</i> has become quite clear now.
Predicate (сказуемые)	<i>who, what, which, how</i>	The problem is <i>how to obtain reliable results</i> .
Object (дополнительные)	<i>when, where, how, who, that</i>	We know from everyday experience <i>that unsupported objects tend to fall toward the ground</i> .
Relative (Attributive) (определятельные)	<i>whose, that, which, who, when, where, how, why</i>	Molecules at the surface of a liquid are subject to forces <i>that attract them to the bulk of the matter</i> .
Adverbial (обстоятельства) of – time (времени) – place (места)	<i>when, while, before, till (until), as, as soon as, since</i> <i>where, wherever</i>	The acceleration is zero <i>only when the speed and direction of motion are both constant</i> . He found it interesting to work <i>where no one expected to get results</i> .

– cause (причины)	<i>because, since, as, for</i>	<i>Since electric currents exert forces, do work, transmit information, and produce electromagnetic waves, they are of major importance.</i>
– purpose (цели)	<i>that, in order that, so that, lest</i>	Glass fibers with low attenuation have been developed <i>so that they can transmit light for many kilometers.</i>
– condition (условия)	<i>if, unless, provided (that), in case</i>	<i>If you know the average velocity</i> , you can use that information to discuss the motion.
– concession (уступительные)	<i>as, however, whoever, whatever, though, although</i>	<i>Although many of the principles of mechanics can be illustrated by objects moving in a straight line</i> , their applications often involve more complex motions.
– comparison (сравнения)	<i>than, as ... as, not so ... as</i>	Fiber-optic cables carry more information <i>than much larger copper cables do.</i>

Mind the translation of the following conjunctions.

where — где, когда
 while — в то время как; пока
 before — до того как; перед тем как
 till (until) — пока ... не
 after — после того как; как только
 as — как; в качестве; когда;
 в то время как; по мере того как;
 так как; поскольку
 as soon as — как только
 whenever — как бы ни; всегда,
 когда; всякий раз как
 wherever — где бы ни; там, где;
 езде, где; куда бы ни; всюду,
 куда (где)
 since — с тех пор как; так как;
 поскольку
 for — так как; ибо; потому что;
 that — чтобы
 in order to — для того чтобы

so that — так чтобы
 lest — чтобы ... не
 if — если
 unless — если ... не
 provided, providing (that) — при
 условии, если
 given — если дано (имеется,
 известно)
 in case — в случае, если
 however — кто бы ... ни; какой
 бы ... ни
 whoever — как бы ни
 whatever — какой бы ни; что бы ни;
 всё, что
 though — хотя; несмотря на то что
 although — хотя; несмотря на то что
 than — чем
 as ... as — так (такой) же, ... как
 not so ... as — не так (такой) же, ... как

2. Read the following extract about the ionizing radiation. Comment on the syntactic structure of the sentences and define different types of clauses. Translate the extract in written form.

The radioactivity decay of nuclei produces several kinds of ionizing radiation with energies that are typically several million electron volts per particle or quantum. When this radiation passes through matter, it leaves a trail of ionized atoms along its path. Even a small amount of ionization can seriously disrupt a sensitive system such as a living cell or a transistor. The term “ionizing radiation” includes both nuclear radiation and atomic X-rays. The less energetic quanta of lower-frequency electromagnetic waves such as visible light and microwaves do not ordinarily cause appreciable ionization. In general, radiation refers only to ionizing radiation in this chapter.

Radiation is an excellent example of an area of science that has been studied intensively by physicists because of its intrinsic interest and that has also become invaluable in applications to many other fields including biology and medicine. Radiation also illustrates with unusual clarity how a scientific advance may, despite its great benefits, have a very large potential for harm. For example, X-ray pictures are often essential in diagnosing a serious illness, but even one X-ray exposure slightly increases the chance of developing cancer. Consequently, all those working with radiation, especially those in the health sciences, have an obligation to understand the physics and biology of radiation and to use it wisely and carefully.

(from *General Physics*)

3. Read the following information about the Relative (Attributive) Clauses.

The scientists who / that *made this discovery* *won a Nobel prize.*

He works for a company *that / which* makes computers.

A **relative** clause contains additional information relating to the main clause of the sentence.

Relative clauses may contain information **essential** to the meaning or purpose of the sentence and define or limit the noun. These clauses are written without commas.

Relative clauses may contain information which, although useful, is not essential to the meaning or purpose of the sentence and can be omitted. These clauses are written with commas.

Compare:

- a. The scientists who used a new device in their experiments got reliable results.
- b. The scientists, who used a new device in their experiments, got reliable results.

Sentence (a) implies that only some of the scientists got reliable results.
Sentence (b) implies that all the scientists got reliable results.

Relative clauses with or without *who / that / which*

You must use *who / that / which* when it is the **subject** of a relative clause. For example:

The scientist who supervises the project will report the results.

|
The scientist supervises the project.

Sometimes *who / that / which* is the **object** of the verb. For example:

The person who you want to see is not available at the moment.

|
You want to see the person.

who (= the person) is the object.

Have you found the keys that you lost?

|
You lost the keys.

that (= the keys) is the object

When *who / that / which* is the **object**, you can leave it out. For example:

The person *you want to see* is not available at the moment.

Have you found the keys *you lost*?

Notice the position of the **prepositions** (*in, at, with, etc.*) in relative clauses:

Are these the keys (that / which) *you are looking for*?

The person (who/ that) *you asked about* is at the seminar now.

4. Use the notes below to write definitions of each of the words in italics using relative clauses where appropriate.

accelerator — an apparatus, or part of a machine — imparts a high kinetic energy — charged particles — electrons, protons, or alpha particles — accelerating them — magnetic fields — high voltage electric fields;

magnetic field — a field of force — exists as a result — presence — conductor — carrying an electric current — a permanent magnet;

cosmic rays — high energy radiation — arrives at the Earth — outer space — consists mainly — charged particles — some gamma rays;

collider — a machine — uses two accelerator beams — collision.

Supplementary material for reading and discussion

Speaking and Writing

The scientist must not only “do” science, he must “write” science.

R. Flesch

1. Read the article carefully and make notes of the views held by a nuclear physicist and an economist on the problem of nuclear power. Find all the arguments “for” and “against” using nuclear energy sources and write them down.

Do we need nuclear power?

With rising fuel costs, concerns about global warming and the growing demand from the developing world for energy, the burning question is whether the world needs nuclear power. **Peter Hodgson**¹, a nuclear physicist, says yes. **Dennis Anderson**², an economist, says that we should first explore the possibilities of renewables and other forms of energy.

Joint introduction

Our civilization and our standard of living depend on an adequate supply of energy. Without energy, we would not be able to heat our homes or cook our food. Long-distance travel and communication would become impossible, and our factories could no longer produce the goods that we need. A century ago the world's energy came almost wholly from coal and “traditional” sources, such as wood, crop residues and animal dung. These are still major sources of energy, particularly in developing

¹ **Peter Hodgson** is a nuclear physicist at Oxford University and has been active in the field since 1948. He has written extensively on the influence of nuclear physics on society and served on the council of the Atomic Scientists Association.

² **Dennis Anderson** is director of the Centre for Energy Policy and Technology, Imperial College, London, former chief economist to the Royal Dutch Shell Group and former economist and energy adviser to the World Bank.

countries, where 2 billion people are without access to, or cannot afford, modern energy forms. Wood and dung are estimated to provide an amount of energy equivalent to 1 billion tonnes of oil each year; it is sobering to realize that this is 16 times more energy than is provided worldwide by nuclear power, and is about the same as the amount of energy provided by coal in Europe and the US combined.

During the 20th century, the world's commercial output and population increased more rapidly than ever before, as did energy consumption, which rose more than tenfold, with a major shift towards oil and gas fuels, and to hydroelectricity and nuclear power. Most of the growth was in industrial nations, where the per capita consumption of commercial fuels is about 10 times that in the developing world.

Energy markets in the industrial countries are maturing, and may even peak and decline with continued improvements in energy efficiency. The last two centuries saw energy efficiency increase enormously — in motive power, electricity generation, lighting, in the use and conservation of heat, and in an array of other applications. There is no evidence that further gains will not be achieved in the future — for example through the use of fuel cells for transport, which could lead to a two- or three-fold increase in fuel efficiency relative to that of the combustion engine, and through distributed sources of combined heat and power. The situation is different in developing countries, where billions of people have hardly enough energy to survive, let alone enough to increase their living standards. If they are to achieve prosperity, their energy needs — which are doubling every 15 years — will have to be met. Moreover, their population will soon be 7–10 times greater than that of the industrial world, and (with the sad exception of several African countries) economic growth is much higher than it is for industrial nations.

If we assume that, after allowing for gains in energy efficiency, the developing world eventually uses only half of the energy per capita consumed by industrial nations today, then the world's energy consumption will still rise more than threefold. Developing nations will therefore need about 5×10^6 MW of new electricity generating capacity in the coming decades, compared with the 1×10^6 MW they have today and the 2×10^6 MW in the industrial nations. (Electricity generation accounts for only about one fifth of our final energy consumption — the rest mainly being for transport and heating.)

Our common ground in debating the question “Do we need nuclear power?” is therefore the fact that the world is likely to need yet more energy, despite the immense amount of energy consumed today. The environmental problems associated with energy production and use will also need to be addressed, including local and regional pollution, and the much discussed problem of global warming.

Yes

Finding ways of satisfying our energy needs is such an urgent problem that we must consider all possible sources, and evaluate them as objectively as possible, *writes Peter Hodgson*. In doing so, it is useful to apply the following criteria: capacity, cost, safety, reliability and environmental effects. No source can satisfy all our energy needs, and although there are several small-scale energy sources, such as solar panels for satellites, we must focus on the major sources.

Wood was a major energy source in ancient times, and is still extensively used in developing countries. It is, however, impractical as a major energy source in developed countries as it occupies much land and adds to atmospheric pollution. Oil, meanwhile, is fast running out and is needed by the petrochemical industry. It is wasteful to burn it, which also adds to pollution. The same applies to natural gas.

Hydropower is an important source of energy, particularly as it is renewable and does not pollute the atmosphere. However, it uses up valuable land and, in any case, the number of suitable rivers is limited. It is unlikely that hydropower will provide for more than about 8% of our energy needs. Tidal power is even more limited by geographical considerations.

The remaining sources — such as wind, solar and geothermal — account for only a few per cent of the global energy consumption. In addition, some of them are unreliable (wind and solar) or intermittent (tidal) and relatively costly. And although the energy in sunshine, wind, waves and tides is enough to satisfy our needs millions of times over, the difficulty is in harnessing these sources in a usable form. Despite continued efforts, wind and solar sources contribute less than 0.5% of our energy production.

This leaves only coal as a major source of energy for at least a few centuries. However, a typical coal-fired power station emits some 11 million tonnes of carbon dioxide each year, as well as 1 million tonnes of ash, 500,000 tonnes of gypsum, 29,000 tonnes

of nitrous oxide, 21,000 tonnes of sludge, 16,000 tonnes of sulphur dioxide, 1,000 tonnes of dust and smaller amounts of other chemicals, such as calcium, potassium, titanium and arsenic. To produce 1 gigawatt-year of electricity requires about 3.5 million tonnes of coal — and this contains over 5 tonnes of uranium. Most of the by-products are caught by filters, but a few thousand tonnes of ash escape, carrying with it a corresponding fraction of the uranium. This accounts for the radioactivity emitted by coal-fired power stations. All the gaseous waste is poured into the air we breathe, and damages our health. To continue to rely on coal could lead to widespread environmental damage and unpredictable climate change.

Can nuclear power provide the energy we need? It already generates about 20% of the world's electricity, including 50% in Western Europe and 80% in France. It is reliable, having high "load factors" — typically more than 90% — with nearly all of the remaining time spent on planned maintenance. Its long-term costs are similar to those of coal. It has little harmful effect on the environment and it is safer than all other sources, apart from natural gas.

Nuclear power only differs from other energy sources in that it emits nuclear radiations. The interior of a nuclear reactor is highly radioactive, and the spent fuel has to be removed periodically for reprocessing. However, the techniques for doing this are well developed and can be carried out safely. The relatively small volumes of highly radioactive residues (nuclear waste) are first stored above ground for several decades to allow the short-lived isotopes to decay, the rest being fused into a insoluble ceramic blocks, encased in stainless-steel containers and buried far below ground in a stable geological formation.

Nuclear reactors can also be improved. While current "thermal reactors" burn only uranium-235, which accounts for just 0.7% of natural uranium, so-called "fast reactors" can burn the remaining 99.3% of the uranium. One reason why fast reactors are not used is because they are more difficult to build, but they will become more economic as uranium becomes more expensive — and could eventually take over from thermal reactors.

Before then, other reactor designs may become available. A particularly promising line of research, which is being pioneered by the Nobel prize winning physicist Carlo Rubbia and others, is into reactors that depend on spallation neutrons from a proton accelerator. The protons hit a target of a heavy metal, such as tungsten, producing a shower of neutrons that

go into a sub-critical reactor assembly. This makes the reactor go critical, thereby generating power. Such reactors are easily controlled because the reaction stops as soon as the accelerator is switched off. The neutron fluxes are also so high that the radioactive wastes can be burnt inside the reactor. These are both highly desirable environmental features. "Pebble-bed" reactors are another promising development.

In the longer term, I have high hopes that fusion energy will ultimately become available. Intensive work is in progress on several possible designs for a fusion reactor. These reactors need deuterium, which is present in water in the proportion of about one part in five thousand. The energy available from fusion reactors is therefore practically limitless.

It is indeed fortunate that, just as other major energy sources are becoming exhausted or are recognized as seriously polluting, a new energy source — nuclear power — has become available to meet our needs.

No

I agree with the relevance of Hodgson's five criteria: capacity, cost, safety, reliability and the environment, *writes Dennis Anderson*. But I find he applies them unevenly toward the three main energy sources under discussion — fossil fuels, renewable energy and nuclear power — with a skew against both fossil fuels and renewable energy. Let me take fossil fuels first, since there is a moral in this for both nuclear power and renewable energy.

The United Nations "Atoms for Peace" conferences in 1955 and 1957, which set the stage for the expansion of the nuclear industry, were unambiguous about the need for nuclear power. The view was that fossil fuels would last for about 75 years and that, by the end of the 20th century, we would be faced with major energy crises unless we had nuclear power. The costs of fossil fuels would rise exponentially, while those of nuclear power would fall.

However, the opposite has happened. Fossil fuels have proven to be abundant and less expensive than nuclear power. Estimates of fossil-fuel reserves are enormous, especially of gas. "Commercially proven" reserves — those that companies have access to and declare in their assets — are a poor guide to actual reserves, which include unexplored resources and unconventional resources such as tar sands, shale oils and gas hydrates.

Estimates suggest that, at current extraction rates, we have over 200 years' supply of oil, 450 for natural gas and over 1,500

for coal, the weighted average being nearly 700 years. Even this is an understatement, since it excludes natural-gas hydrates in the permafrost and under the ocean floors, and other sources that together are thought to amount to five times these values.

Moreover, the oil, gas and coal industries have made tremendous advances in exploration and production, and the electricity industry is steadily improving the thermal efficiency of fossil-fuel power stations. Estimates of reserves have increased more than tenfold, and costs have declined relative to those of nuclear power. Indeed, if nuclear power were to compete commercially with a natural-gas-fired power station, it would need a subsidy of more than £1bn per gigawatt.

It is, of course, easy to speak with the wisdom of hindsight, and to overlook the uncertainties and risks that the energy industry faced when nuclear-power programmes were being put in place. In the 1950s nuclear power held the promise of unlimited energy in an era when coal mining was an arduous, dangerous and unhealthy occupation for millions of workers (as it still is in China and India), when fuel shortages were common, and when coal burning in homes and industry was the source of intolerable levels of local pollution.

Nevertheless, nuclear power has been unable to compete in terms of cost with fossil fuels, and there is no commercial interest in it outside state-run electricity sectors. The subsidies for nuclear power over the past five decades have been colossal — about a hundred times the amount we have spent on developing renewable energy, for example — and further immense subsidies will be required to deal with the legacy of nuclear wastes and the decommissioning of power stations. Indeed, following the privatization of the electricity industry in the late 1980s, the UK introduced a Non Fossil Fuel Obligation (NFFO) to support nuclear power; it injected £8bn of subsidies into the industry *after* it had been sold off while another £5bn is reportedly needed to deal with the decommissioning of the Dounreay nuclear facility. The NFFO, in contrast, injected just £750m (less than 10% of the funds) into renewable energy.

It is true that nuclear power makes a sizeable contribution to energy supplies in France and the UK, and that global production grew from near zero to the equivalent of 630 million tonnes of oil (toe) per year between 1960 and 2000. But the energy obtained from biomass — albeit unsustainably gathered over large areas — also increased by almost as much, in absolute terms, as that obtained from nuclear power. The contribution of fossil fu-

els rose by seven times this amount, notwithstanding the predictions that they would be nearly exhausted by the year 2000.

In terms of capacity and cost, it is thus difficult to make a good case for nuclear power. Fossil fuels are more than sufficient to meet the world's energy needs economically, not least in developing countries. Will environmental concerns change this? In response to successions of clean-air acts and environmental controls introduced in industrial nations, all sectors of the energy industry have made immense strides in reducing local and regional pollution per unit of energy consumption.

With the partial exception of nitrous oxides, the development of "clean" technologies and fuels is enabling pollution per unit of energy use to be reduced by several orders of magnitude. We have seen major reductions in local and regional pollution where these technologies and practices have been introduced: reductions of smog, lead in fuels and acid deposition in Europe and the US being striking examples. The associated costs have, moreover, proved to be small compared with the overall costs of energy use, and have sometimes been negative, with the "clean" practice being more efficient than the polluting practice it displaced. Further reductions are still possible, with hybrid vehicles and fuel cells holding considerable promise. Countries taking advantage of these technological developments have been able to use more energy with less pollution and have found themselves economically better off.

The fossil-fuel industry has thus responded remarkably well to local and regional pollution problems, and there is no reason why societies cannot enjoy the benefits of using these sources while striving to improve the local and regional environment. I shall tend to the global environment later.

Yes

Anderson observes that fossil fuels have proven to be abundant and less expensive than nuclear power. It is not surprising that estimates of reserves differ, because surveys are inevitably incomplete. Furthermore, the quantities available depend on how much we are prepared to pay for extraction. Relative costs are difficult to estimate because nuclear costs depend on the lifetime of the reactor, which may be as long as 60 years. A small fraction of the output invested each year easily pays for decommissioning, and reactors are now designed to facilitate this process. The cost of nuclear power relative to fossil fuels would be very different if realistic estimates of the cost of pollution and

climate change were also included. In the short term, fossil fuels may appear less expensive, but it is the long term that is more important.

The Belgian government recently set up a commission to examine the options for electricity generation. Taking into account fuel costs, non-fuel costs (investment, operation and maintenance), external costs (air pollution, noise and greenhouse gases) as well as the cost of construction, grid connection and decommissioning, the commission estimated that it will cost BFr 2.34 to generate every kilowatt-hour of electricity from coal in 2010. The equivalent figures were 1.74 for gas, wind as 1.85 (seashore), 2.39 (off — shore) and 3.26 (inland), but just 1.22–1.28 for nuclear power. In other words, nuclear power is not only more reliable, safer and less detrimental to the environment than the alternatives, but also substantially cheaper.

In his book *The Earth Under Threat*, Sir Ghilleen Prance, former director of the Royal Botanical Gardens at Kew, describes in graphic detail the devastating effect on animal and plant life already attributable to climate change. Many species, such as the golden toad in Costa Rica, have become extinct. This can be dismissed as anecdotal and lacking in statistical basis. Who cares about the golden toad? Well, I do, as I care about all threatened species.

Scientists on the UN's International Panel for Climate Change (IPCC) have amassed impressive evidence that climate change is real. Their work indicates that in the next 100 years average global temperatures will rise by several degrees and the sea level by 50–100 cm. There are, of course, many uncertainties, but it is prudent to take climate change seriously. Many of its potentially devastating effects are directly attributable to the carbon dioxide emitted when fossil fuels are burnt. Meanwhile, impurities in fossil fuels cause acid rain, which is already adversely affecting rivers, lakes and forests. While some countries are reducing the levels of pollution, this must be done world wide. It is therefore essential to eliminate fossil-fuel power stations.

As for wind and solar power, they contributed only 0.15% of the world's energy production in 2000 and disfigure large areas of land. They are also relatively expensive and five times as dangerous as nuclear power as measured by deaths from all causes during production. There is no hope that they can supply our energy needs. The only practical substitute for fossil fuels is nuclear power. In 1988 some 1.9×10^{12} kW·h of electricity was generated by nuclear power stations. The same amount would

be produced by burning 900 million tonnes of coal or 600 million tonnes of oil. In other words, the emission of 3,000 million tonnes of carbon dioxide has been saved by using nuclear power, rather than coal. (While coal emits 850 tonnes of carbon dioxide per gigawatt hour, the figures for oil are 750, gas 500, nuclear 8, wind 7 and hydro 4.)

As countries switch to nuclear, their rate of carbon-dioxide emissions falls. Since 1970 France has halved its emissions, Japan (32% nuclear) has achieved a reduction of 20%, while the US (20% nuclear) has reduced it by only 6%. The emission of noxious gases like sulphur dioxide is also dramatically reduced by going nuclear.

The UK government, meanwhile, wants its emissions of greenhouse gases to be 10% lower by 2010 than they were in 1990. A reduction of 6% had been achieved by 1995, which was due to nuclear-power output rising by 39% between 1990 and 1994. However, if no more nuclear power stations are built, the level of emissions will rise steeply. In subsequent years, as older nuclear power stations are decommissioned, the UK will find it impossible to reach its target.

Although many new gas-fired power stations, which emit only half as much carbon dioxide as coal-fired power stations, are currently being built, the problem is that they leak methane, which has a "global-warming potential" of about 60 times that of carbon dioxide. These two effects approximately balance out, which means that we can expect no reduction in global warming by switching from coal to gas. Even if this methane effect is neglected, then if gas increases to 43.5% of total production, while coal declines to 2.5%, we can expect carbon-dioxide emissions to fall by 10%. And if nuclear rises to 43.5% at the expense of coal there will be a 20% fall.

If we do not solve the world's energy problems now, then they will soon be solved for us. We are living in a special period in human history when oil, gas and coal are readily available. At present rates of consumption, the oil and gas will be gone in less than 100 years, and coal in about 200–300 years. Fossil-fuel burning will then cease and alternatives will have to be found. If we continue to burn fossil fuels, we not only pollute the Earth and initiate global warming, we also deprive future generations of these valuable materials, the bases of petrochemical industries. Would it not be better to solve these problems now — using nuclear power — instead of waiting until it is too late?

No

I disagree with Hodgson that “the only practical substitute for fossil fuels is nuclear power”. The alternative of renewable energy is abundant, as he points out, but its *practical* potential is also far greater than he suggests. It could, in theory, meet *all* of the world’s energy demands. In practice, we will end up with a mix of energy supplies. Hydrogen production from coal-bed methane and natural gas is a promising option, for example (the CO₂ by-product being used for the enhanced recovery of oil or coal-bed methane on a non-net-carbon-emitting cycle). This is not merely my view: the IPCC, in all three of its assessment reports, has arrived at the same conclusion, as have many industrial and academic studies. First two myths about renewable energy need to be dispelled. One is that it is too dispersed to be of practical use without despoiling the landscape. Over vast areas of the developing world, the incident solar energy is 2,000–2,700 kW·h per square metre of ground occupied per year. Solar-thermal power stations can convert more than 20% of this to electricity, and photovoltaics now on the market about 15% of it. This is more than two orders of magnitude higher than the energy produced by common crops and wood from an equivalent area of land. All of the world’s future energy demands could, in theory, be met by solar devices occupying about:

- 1% of the land now used for crops and pasture; or
- the same area of land currently inundated by hydroelectric schemes, the electricity yield per unit area of solar technologies being 50–100 times that of an average hydro scheme.

A sizeable portion of energy supplies could also be produced by roof-top solar devices. Nor should we overlook resources such as biomass (which could enable vast areas of degraded land in developing countries to be restored), as well as offshore wind, geothermal energy and the energy in tidal streams and waves. Although I share Hodgson’s concerns about the dangers of wind turbines despoiling the landscape, they are now being installed offshore. Multi-sourced systems based on wind, waves, tidal streams and solar power are also possible. Solar schemes are also architecturally attractive.

The second myth is that renewable energy (other than biomass) cannot be stored. A range of options is now being developed, including thermal, mechanical, thermochemical and electrochemical storage, as well as the production and storage of hydrogen for fuel cells or direct combustion for both stationary applications and transport. Even nuclear power needs to solve

its "storage problem", both to service peak loads on electricity systems and to meet the immense energy needs of transport.

Producing hydrogen from solar photovoltaics and wind power is estimated to cost between £0.05–0.10 per kilowatt-hour, roughly 7–15 times the cost of natural gas. However, the costs could decline fivefold with economies of scale and as the manufacture of electrolyzers develops. And although nuclear power has the economic advantage of using the capacity of electrolyzers more fully, the long-term average costs of renewables are as low as — if not lower than — those of nuclear power. Renewable-energy-hydrogen systems are unlikely to cost more than nuclear — hydrogen systems — and possibly less.

The costs of renewable-energy technologies differ greatly with location. Solar technologies are more economical in the sun-drenched tropics, where seasonal variations in sun levels are lower than in other regions of the world and solar peaks match demand peaks much better. In fact, solar technologies are over five times cheaper per kilowatt-hour for most developing nations. What might look a distinctly unpromising technology to a pessimist on a rainy day in northern Europe is highly promising where 5 billion of the world's population live, and where energy demands are growing fastest.

There is already a rapidly growing market in the developing world for applications that use the Sun for water pumping, lighting and health clinics, and as a back-up for grid supplies and to supplement peak loads. Solar applications also avoid the capital expenditures on — and losses in — transmitting and distributing electricity, which account for about 50% of the costs of electricity supply in urban areas and over 75% in rural areas and towns. Fuel cells as decentralized sources of electricity generation — using hydrogen generated from renewable energy — would give rise to similar savings and, in colder climates, would be an efficient source of combined heat and power.

All of these renewable technologies are proven options and are fertile areas for R&D; the literature is notable for the range of advances that are being reported, not least in conversion efficiencies. They are still in an early phase of development, significant efforts having begun barely two decades ago. The technologies are modular and well suited for batch production. The lead times are just a few months, compared to 7–10 years for nuclear reactors and 3–5 years for fossil-fuel power stations. This is an important source of cost savings and allows the technologies to

be developed quickly. They can also be decommissioned and the materials recycled relatively easily.

Such factors will not, of course, guarantee economic success, and it will be important to develop economically viable storage systems, including the fuel-cell hydrogen option. But they do suggest that we have energy sources of immense promise if we are prepared to support them through wise policies.

It is hard to overstate the size of the task if we are to replace fossil fuels by renewable or nuclear energy to mitigate the effects of climate change. According to the IPCC and the World Energy Assessment — which was carried out last year by the UN Development Programme and the World Energy Council — global primary-energy demands will rise from about 400×10^{18} J today to $800\text{--}1600 \times 10^{18}$ J by the end of the 21st century, depending on assumptions about energy efficiency. This is equivalent to the output of 15–30 million MW of nuclear power.

Given the huge problems of decommissioning and waste disposal, the share of nuclear power in meeting future energy needs is bound to be limited. We cannot rely on nuclear power to solve the climate-change problem. We should therefore develop ways of using solar power — the one safe and abundant form of fusion energy that is already available to us in perpetuity. I appreciate how far developments in renewable energy and hydrogen-powered fuel cells have to go, the difficulties and risks of developing an industry from a small base, and the time it will take to switch from fossil fuels. But we must explore and develop these options.

Yes

Meeting the world's energy needs is an urgent problem — and all practicable energy sources must be used to solve it. The exact mix in different regions will depend on many factors, particularly the indigenous fuels as well as local geography and economics. Developed countries must help developing nations to increase their energy supplies and curb existing wasteful habits. Continuing efforts must be made to reduce pollution and carbon dioxide emissions. To make progress in discussions about energy production and the effects on the environment, it is essential to have numerical data. Without such information, it is impossible to know whether a proposed source or effect is important or negligible. If we are to stabilize the emission of carbon dioxide by the middle of the 21st century, we need to replace 2,000 fossil-fuel power stations in the next 40 years, equivalent to a rate of one per week. Can we find 500 km^2 each week to install 4,000 wind-

mills? Or perhaps we could cover 10 km² of desert each week with solar panels and keep them clean? Tidal power can produce large amounts of energy, but can we find a new Severn estuary and build a barrage costing £9bn every five weeks?

Nuclear power, however, is a well tried and reliable source, whereas the alternatives listed by Anderson are mainly hope for the future and have yet to prove themselves. At the height of new nuclear construction in the 1980s, an average of 23 new nuclear reactors were being built each year, with a peak of 43 in 1983. A construction rate of one per week is therefore practicable.

I hold no special belief for nuclear power. If there were another way of providing our energy needs without destroying the Earth, I would support it. I am not, I must admit, happy about the dangers of nuclear radiation. I know that, in the hands of engineers at, say, Sizewell, nuclear power is extremely safe, but I can think of many places that would not inspire me with the same confidence. There is always the fallibility of human nature, and the danger that politics will domineer engineering prudence, although the same could be said of all modern technology. Strict controls and eternal vigilance are therefore the price we must pay for its benefits.

A careful and objective analysis will reveal the best energy policies to adopt. It is all too likely, however, that this will not coincide with public views. This puts governments in a dilemma; they can remain popular only by adopting policies that they know are not the best ones from an objective scientific viewpoint. Methods of tackling this serious and intractable problem will have to be discussed.

So do we need nuclear power? Obviously not, if all we care about is having enough energy for the next 100–200 years to continue our current wasteful lifestyles. But then we must pay the price in terms of pollution: sterile lakes and dying forests, climate change and the international tensions generated by the scramble for the last remaining oil. To avoid these consequences, such fuels must be replaced by non-polluting sources, and the only realistic possibility is nuclear power. If we care for the Earth, then, like it or lump it, we need nuclear power.

No

I believe industrialized nations should adopt a modest carbon tax with the revenues being earmarked for R&D and tax incen-

tives to commercialize the following technologies:

- offshore renewable-energy resources;
- hydrogen systems and fuel cells;
- photovoltaics;
- advanced energy-storage systems, including hydrogen storage;
- geothermal energy; and
- improved energy efficiency, including small-scale systems that combine both heat and power.

Although industrial countries, including the UK, are already heading in these directions, their policies are minuscule in comparison with the effort they expended on nuclear power in the past.

Developing countries also need to initiate parallel programmes. Building on the work of the UN Framework Conventions on climate change and biodiversity, these programmes should — in addition to the above policies — include the development of advanced solar-thermal power stations and multi-purpose schemes for the sustainable production of biomass for energy use and the restoration of degraded lands and watersheds.

It is *precisely because* renewable energy still accounts for such a small share of output, coupled with its promise, that these programmes are justified from both an economic and an environmental perspective. When promising technologies are emerging, they need to be nurtured and researched more fully, to see what they will yield. Of all the arguments against renewable energy, the one that it still accounts for only a small fraction of output relative to nuclear power is the worst. Nuclear power generated little in the 1950s; but that did not stop governments subsidizing the industry to the tune of \$0.5–1 trillion over the following 40 years. In the early phases of a technology, there is more to be discovered, more scope for progress, more scope for reducing costs through invention and innovation, and economies of scale are more marked. The costs of photovoltaic modules, for example, fell from \$300,000 per kilowatt in the 1970s to \$3,000 per kilowatt by the late 1990s, and the scope for further reductions is far from exhausted.

The “learning curves” for renewable -energy technologies are steep, the unit costs falling by 15–25% every time the cumulative volume of production doubles. There is every indication that fuel cells and hydrogen production will decline in cost at a similar rate, provided that we invest in their development. Indeed, over 5 GW of new renewable-energy capacity is already being

installed each year, and markets are doubling every 3–4 years. If their share in energy production rose to 5–10% of world energy supplies, their costs would decline by three- to fivefold. At worst, we would have an important source of energy supplies; at best, a proven way of meeting the world’s energy needs in perpetuity without carbon emissions, and a cheaper and abundant source of energy — most of all in developing nations.

As for nuclear power, it should be exempted from carbon taxes and climate-change levies. To put a carbon tax on non-carbon energy sources is illogical and inappropriate. The huge legacy of nuclear waste and the decommissioning of old nuclear plants must also be addressed by public policies. Beyond that, the nuclear industry is now surely mature enough to stand on its own feet. It does not merit further public financial support, which would be better used for other purposes. It should put the case for new plant to the financial markets, not to governments, and in doing so make the necessary provisions for meeting the costs of waste disposal and eventual decommissioning.

Table 1. Global primary-energy consumption

<i>Energy source</i>	<i>1860</i>	<i>1900</i>	<i>1950</i>	<i>2000</i>
Traditional (wood, dung, etc)	270	330	470	~1000
Coal	100	470	1300	2220
Oil		20	470	3400
Natural gas			170	2020
Hydro-electric		10	120	230
Nuclear power				630
Renewable (other than hydro)				~200
Total	370	830	2530	~9700

(In million tonnes of oil (toe) equivalent energy)
(from *Physics World*, June 2001)

2. **Speak about different approaches to the problem under discussion, compare and contrast different opinions.**
3. **Write a passage summarising different views of using nuclear power to meet our energy needs. Present your arguments and make generalisations. You can begin in the following way:**

One of the main arguments against / in favour of using nuclear power to meet our energy needs is that...

Before writing study the following words and phrases which will help you to mark stages in a discussion, to introduce your own point of view, to express agreement or disagreement.

a) You can mark the order of items or degrees of importance.

Example: First / Firstly / First of all / In the first place / The most important...
Second / Secondly / In the second place / The next most important...
Next / Then / After this (that) / Following this (that)...
Finally / Lastly / In conclusion...

b) You can introduce your point of view.

Example: The first thing } we have }
First of all } I should like } to consider ...
The first thing to be considered is...
It is a fact / There is no doubt / I believe that...
One of the main arguments in favour of / against smth is that...

c) You can express agreement or disagreement.

Example: I (dis)agree with N when he writes / says that...
N may be correct when he says / is saying that... (cautious agreement)
N is certainly correct when he says / writes that... (emphatic agreement)
I completely agree with N when he says / writes that... (emphatic agreement)

d) You can give emphasis to what is written by using “negative inversion”.

Example: Rarely had such a view been supported.
Never / Not only ... but also / Under no circumstances /
On no account / Seldom / Neither...

4. Write an essay on the topic: *Nuclear Power: For and Against*. You should write at least 500 words.

• Mind that an essay should be clearly structured. It has

1) an introductory paragraph giving an overview of the content in sequence;

2) the main body;

3) a conclusion that follows logically from what has been written before and involves a summary of the main points already made; it may include commenting on the implications arising from the main body of the writing: possibly indicating that further research is needed or that certain action is to be taken; your own point of view may be added.

- **Introductions commonly include these elements:**

stating the topic

description of $\left\{ \begin{array}{l} - \text{problem to be considered} \\ - \text{historical background} \\ - \text{structure of the writing and sequence of main points} \end{array} \right.$

definition and / or explanation of the subject

Example: In this essay ... will be examined. First the arguments in favour will be considered and then the arguments against. Finally, it will be shown that ... appears to be the most urgent problem.

To summarise and conclude you can use the following:

In short, ...

In a word, ...

In brief, ...

To sum up, ...

In conclusion, ...

On the whole, ...

Altogether, ...

In all, ...

Therefore,

Thus,

On this basis,

Given this,

$\left. \begin{array}{l} \text{Therefore,} \\ \text{Thus,} \\ \text{On this basis,} \\ \text{Given this,} \end{array} \right\} \text{ it can / may be}$

$\left\{ \begin{array}{l} \text{deduced} \\ \text{concluded} \\ \text{inferred} \end{array} \right.$

$\left. \begin{array}{l} \text{deduced} \\ \text{concluded} \\ \text{inferred} \end{array} \right\} \text{ that...}$

- **Notice that in academic writing you should be careful about any claims that you make. Look at such “cautious” language and use it in your essay where appropriate.**

Impersonal verb phrases

It appears to / that

It seems to / that

It tends to

There is a tendency to / for

Some of the evidence shows that

It has been suggested that

It is generally agreed that

It is widely accepted that

It is now generally recognised that

Adverbs expressing caution

apparently — очевидно

approximately — приблизительно

hardly — едва ли

practically — практически

presumably — по-видимому

relatively — относительно

scarcely — едва ли

seemingly — по-видимому

slightly — немного

virtually — фактически

Some of the probability qualifications can be given. For example:

It is	fairly	certain likely	that...
	very quite	probable possible likely unlikely	
	rather	unlikely	
	almost quite	certain	

Sometimes generalisations may be introduced or qualified in the following way:

In the (vast) majority / a (large) number of cases...

In most / some / a few cases...

- **Study the scale of qualification. It will help you to make your generalisations more precise.**

Per- cent- age guide	Quantity	Frequency	Probability		
			Adverbs	Adjectives	Verbs
100% 	all / every / each / most a majority (of) many / much a lot (of) enough	always	certainly definitely undoubtedly clearly presumably probably	certain definite undoubted clear un(likely) probable	will is / are must/have to should would ought to
	some a number (of) several	usual(ly) normal(ly) general(ly) on the whole regular(ly) often			may might can could
	a minority (of)	sometimes occasional(ly)	conceivably possibly perhaps maybe uncertainly	possible	
	a few / a little few / little	rare(ly) seldom hardly ever		uncertain	will not is / are not can not could not
0%	no / none / not any				

- **Here are some hints on effective writing.**

1. Go from old to new information.
2. Avoid interrupting the main clause with a subordinate clause if the interruption may cause confusion.
3. Use active voice.
4. Use parallel constructions.

5. Avoid noun strings.
6. Avoid overusing noun forms of verbs.
7. Avoid overusing preposition *of*.
8. Avoid multiple negatives.
9. Choose action verbs over forms of *be*.
10. Avoid unclear pronoun references.
11. Avoid using too lengthy sentences.

Project Work

Divide yourselves into small groups (perhaps 3–4) with each person responsible for one aspect or part of the activity. Afterwards you will need to put all your information together and organise a round-table discussion on the topic: ***Energy and the Environment***. Your project should involve investigating various sources of information or references, in the library or in the Internet. You are also expected to use visual aids (diagrams, graphs, pictures, tables, etc.) to stimulate discussion. The following information will be most useful.

Presenting visual aids

*Talking about the content of visual aids (a diagram, a line / bar graph, a pie chart, a table etc.) draw attention to **rows** and **columns** in a table and **segments** in a pie chart; to a **vertical / horizontal axis**, a **solid / dotted / broken / fluctuating / undulating line** in a graph.*

Follow this advice.

- Write clearly.
- Do not stand in front of the visual aid.
- Do not use too much detail. Choose just two or three main points to emphasise.
- Do not turn your back on the audience.
- Keep eye contact at least 80% of the time.

Here is the typical structure in the description of a visual (a graph)

Introduction What the graph is about
Explanation What the two axes represent
Message Highlight key information

You may introduce a visual in the following way.

I'd like to show you...

Have a look at this...

This (graph) shows / represents...

Here we can see...

Let's look at this...

Here you see the trend in...

To compare you may use these phrases.

This compares... with...

Let's compare the...

Here you see a comparison between...

1. Look through these presentations of a graph, a pie chart and a table and use them as models.

a) Now, *I'd like to show you this graph.*

It shows the rate of increase in fossil fuel consumption since the mid-19th century.

On the left hand vertical axis you see fossil fuel consumption measured in gigatonnes of carbon, while *the horizontal axis shows* time in years. *On the right hand axis you can see* the three main types of fossil fuel: coal, oil and gas. *What we can see here* is, quite clearly, *an extremely sharp rise in* fossil fuel consumption and *a trend towards* more oil and gas.

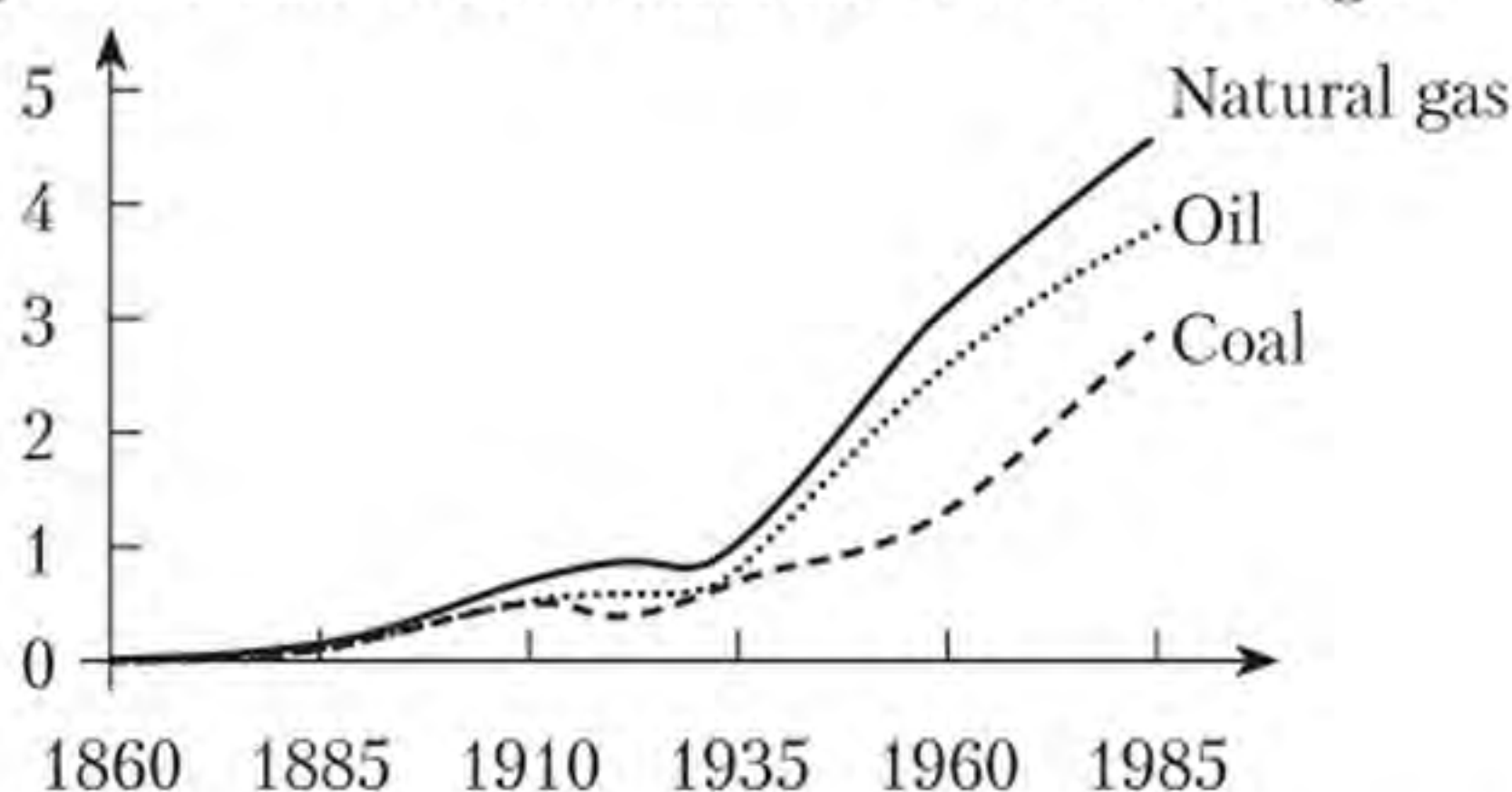


Fig 1. Growth in fossil fuel consumption since Industrial Revolution over a period of 125 years

b) Now, the picture here, *a pie chart, shows* the relative consumption of fossil fuels in 1990. *The main points to note are that the largest consumption is* for oil — as you'd expect — at 33%. *The next largest is* coal at 27%. Perhaps a little surprising, the smallest here is nuclear fuels... nuclear energy... only at 5%. Quite little.

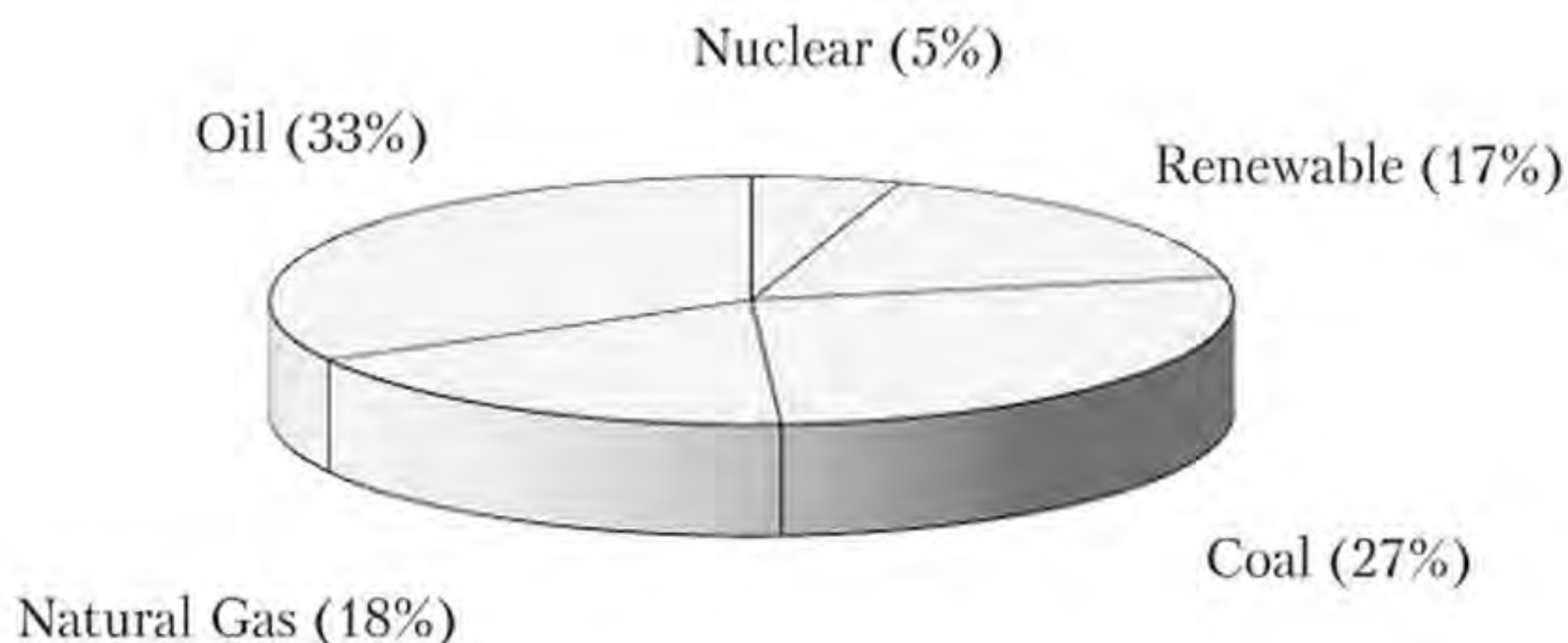


Fig. 2. Relative consumption of fossil fuels (1990)

c) Finally, *have a look at the table* here. Now *this table shows* CO₂ emissions *and compares* different European Community countries over three different years, *the first column is* 1980, *the middle column is* 1986 and *the last one is* 1989. *If we look at the totals we see that* emissions of CO₂ actually *fell from* 2,747.1 million tonnes in 1980 *to* 2,492 million tonnes in 1986. *That trend wasn't continued as the figure rose again to* 2,562.9 in 1989. *The other striking observation from this table is* the heavy contribution to CO₂ emission from Germany and Britain. German emissions were at least falling but in 1989 stood at 647.9 million tonnes. The most impressive fall is in France, from 459.2 to 360.6, much lower than either Germany or Britain.

Table 2. Carbon dioxide emissions: major EU countries

<i>Million tonnes CO₂</i>			
	<i>1980</i>	<i>1986</i>	<i>1989</i>
United Kingdom	528.7	525.9	530.1
Belgium	120.0	95.4	99.1
France	459.2	353.2	360.6
Germany	767.5	675.3	647.9
Italy	355.5	343.2	386.1
Spain	196.2	176.1	194.9
European Community	2747.1	2492.0	2562.9

2. Suggest your description of the graph below, taken from a presentation about air quality. Use the prompts.

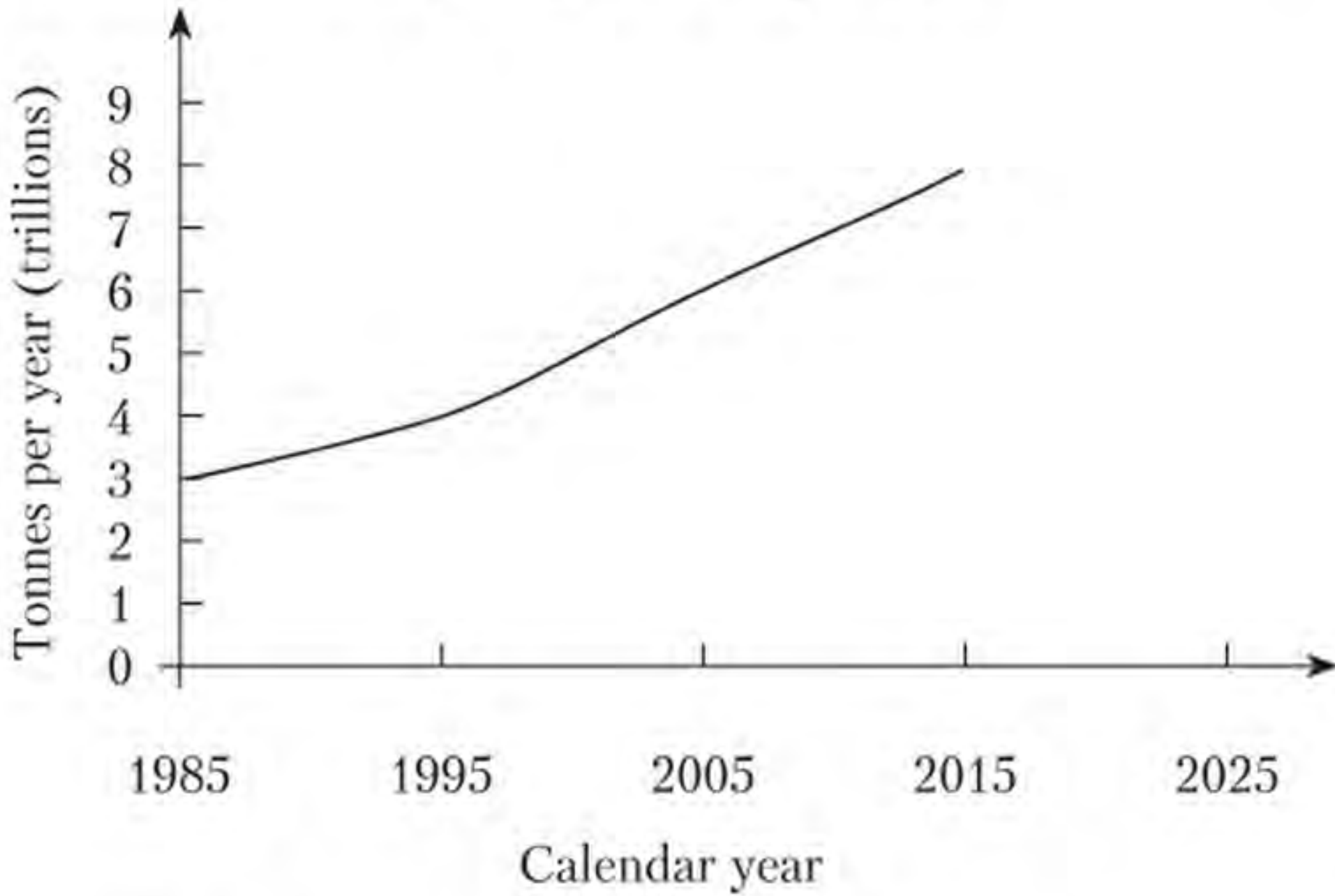


Fig 3. Global vehicle CO₂ emission assuming no improvements in vehicle efficiency

- a) Now...
- b) It shows...
- c) The vertical axis... while...
- d) Clearly, we can see that...

Compare your variant with the key.

- a) Now let me show you a picture here.
- b) It shows global vehicle carbon dioxide – CO₂ emissions, with no improvements in vehicle efficiency.
- c) The vertical axis shows trillions of tonnes per year, while the horizontal axis shows time in years from 1985 to 2025.
- d) Clearly, we can see that carbon emissions are rising at a tremendous rate.

3. Turn back to the text about nuclear power. Look carefully at the information in Table 1. Comment on the trends of energy consumption shown in the table.

You may begin in the following way: As can be seen from the table, during the period 1860 to 2000 there was a considerable increase in the global energy consumption. At the beginning of the period the consumption was ... and by the end had grown to The fastest growth was from ... to

Now show the trends of different energy sources for 140 years from 1860 to 2000. You may use the following for

a) describing change

There was a(n) (very)	minimal slight small slow gradual steady marked large dramatic steep sharp rapid sudden	rise increase fluctuation decrease decline reduction fall drop
-----------------------	---	---

b) comparing

in relation to... compared with...	twice three times	as...	high large many	as...
	half of double treble	(that)		
	double treble half	the	percentage number	of

4. Select two or three main points for special emphasis in your explanation for the information from the table below.

Table 3. Trends in CO₂ emissions

Billion tonnes CO ₂			
	1990	2000	2010
France	0.39	0.41	0.39
Germany	1.02	0.87	0.82
Italy	0.43	0.46	0.42
Spain	0.23	0.31	0.28
United Kingdom	0.59	0.55	0.51
Netherlands	0.16	0.17	0.18
European Community	2.82	2.77	2.60

Source: Trends in global CO₂ emissions: 2013 Report (edgar.jrc.europa.eu/news_docs/pbl-2013-trends-in-global-co2-emissions-2013-report-1148.pdf)

5. Find information on different fuels that contribute to the world's energy consumption in the 21st century. Draw a pie chart showing the data on gas, oil, coal, nuclear fuel, hydro-power, biomass and other renewable sources of energy. Comment on the most significant items.

Making meetings effective

Do you know what makes a good meeting?

Here are the characteristics of a successful meeting:

- good preparation
- clear objectives
- good chairing
- respect for the timing
- polite discussion

Note the main functions of the chairperson in the discussion.

- a) Start and end on time.
- b) Welcome the participants to a meeting.
- c) State the objectives and introduce the agenda.
- d) Define time limits for contributions.
- e) Introduce the speakers.
- f) Prevent interruptions.
- g) Thank the speakers for their contributions.
- h) Control discussion, hear all views.
- i) Summarise discussion at key points.
- j) Close the meeting.

Make good use of the language of chairing a meeting and leading discussion.

Opening the meeting

Welcome, everybody. Thank you for coming.

Introducing the agenda

You've all seen the agenda...

On the agenda, you'll see there are three items.

There is one main item to discuss...

Stating objectives

We're here today to hear about...

Our objective is to discuss different ideas...

What we want today is to reach a decision...

Introducing discussion

The background to the problem is...

The issue is about...

The point we have to understand is...

Calling on a speaker

I'd like to ask Mrs. Brown to share her views on... / to tell us about...

Can we hear from Mr. Snow on this?

Now, can I ask Ms. Black to tell us her views ...?

Controlling the meeting

Sorry Mr. Blake, can we let Mrs. Brown finish?

Er, can we try to keep to the topic?

Summarising

So, what you're saying is...

Can I summarise that? You mean...

So, the main point is...

I'd like to sum up the main points.

Moving the discussion on

Can we go on to think about...

Let's move on to the next point.

Closing the meeting

I think we've covered everything.

I think we can close the meeting now.

Thank you. That's everything. That's it for today.

Check whether you know how to state opinion, ask for opinion, interrupt and handle interruptions during a discussion.

Stating opinion

It seems to me...

I tend to think...

In my view...

There's no alternative to...

It's obvious that...

Clearly / obviously...

Asking for opinion

I'd like to hear from...

Could we hear from ...?

What's your view?

What do you think about ...?

Do you have any strong views on ...?

Any comments?

Interrupting

Excuse me, may I ask for clarification on this?

If I may interrupt, could you say ...?

Sorry to interrupt, but...

Do you think so? My impression is...

Handling interruptions

Yes, go ahead.

Sorry, please let me finish...

If I may finish this point...

Can I come to that later?

That's not really relevant at this stage...

Can we leave that to another discussion?

Appendix 1

Word Index

account 4	feature 4
achieve 3	follow 4
agree 4	general 2
apply 4	investigate 4
approach 3	knowledge 4
argue 5	law 3
available 5	object 2
challenge 3	occur 5
change 3	particular 2
common 2	provide 4
concept 3	realize 4
concern 4	reason 2
conclude 5	relate 5
condition 5	require 2
consider 5	research 5
contribute 3	respond 2
correspond 2	result 5
describe 5	science 2
determine 5	theory 3
develop 3	treat 3
discover 3	use 2
evidence 4	vary 2
examination 5	view 4
experiment 3	way 2

Appendix 2

List of Chemical Elements

- Ag — argentum [ɑ:ˈdʒentəm] = silver [ˈsɪlvə] серебро
Al — aluminium [ˌæljʊˈmɪniəm] = aluminum [əˈluːmɪnəm] (US)
алюминий
Ar — argon [ˈɑːɡɒn] аргон
As — arsenic [ˈɑːs(ə)nɪk] мышьяк
Au — aurum [ˈɔːrəm] = gold [ɡəʊld] золото
B — boron [ˈbɔːrɒn] бор
Ba — barium [ˈbe(ə)rɪəm] барий
Be — beryllium [bəˈrɪliəm] бериллий
Bi — bismuth [ˈbɪzməθ] висмут
Br — bromine [ˈbrəʊmiːn] бром
C — carbon [ˈkɑːbən] углерод
Ca — calcium [ˈkælsiəm] кальций
Ce — cerium [ˈsi(ə)rɪəm] церий
Cd — cadmium [ˈkædmɪəm] кадмий
Cl — chlorine [ˈklɔːriːn] хлор
Co — cobalt [ˈkəʊbɔːlt] кобальт
Cr — chromium [ˈkrəʊmiəm] хром
Cs — caesium [ˈsiːziəm] цезий
Cu — copper [ˈkɒpə] медь
F — fluorine [ˈflu(ə)rɪːn] фтор
Fe — ferrum [ˈferəm] = iron [ˈaɪən] железо
Ga — gallium [ˈɡæliəm] галлий
Ge — germanium [dʒɜːˈmeɪniəm] германий
H — hydrogen [ˈhaɪdrədʒən] водород
He — helium [ˈhiːliəm] гелий
Hg — hydrargyrum [haɪˈdrɑːdʒɪrəm] = mercury [ˈmɜːkjʊrɪ] ртуть
I — iodine [ˈaɪədiːn] йод
Ir — iridium [ɪˈrɪdiəm] иридий
K — kalium [ˈkeɪliəm] = potassium [pəˈtæsiəm] калий
Li — lithium [ˈliθiəm] литий
Mg — magnesium [mæɡˈniːziəm] магний

Mn — manganese [ˌmæŋɡəˈniːz] марганец
 Mo — molybdenum [məˈlɪbdənəm] молибден
 N — nitrogen [ˈnaɪtrədʒ(ə)n] азот
 Na — natrium [ˈneɪtriəm] = sodium [ˈsəʊdiəm] натрий
 Ne — neon [ˈniːɒn] неон
 Ni — nickel [ˈnɪk(ə)l] никель
 O — oxygen [ˈɒksɪdʒ(ə)n] кислород
 P — phosphorus [ˈfɒsf(ə)rəs] фосфор
 Pb — plumbum [ˈplʌmbəm] = lead [led] свинец
 Pt — platinum [ˈplætɪnəm] платина
 Pu — plutonium [pluːˈtəʊniəm] плутоний
 Ra — radium [ˈreɪdiəm] радий
 Rb — rubidium [ruːˈbɪdiəm] рубидий
 S — sulphur [ˈsʌlfə] сера
 Sb — antimony [ˈæntɪməni] сурьма
 Sc — scandium [ˈskændiəm] скандий
 Se — selenium [siˈliːniəm] селен
 Si — silicon [ˈsɪlɪkən] кремний
 Sn — stannum [ˈstæənəm] = tin [tɪn] олово
 Sr — strontium [ˈstrɒntiəm], [ˈstrɒnʃiəm] стронций
 Te — tellurium [təˈl(j)u(ə)riəm] теллур
 Th — thorium [ˈθɔːriəm] торий
 Ti — titanium [t(a)ɪˈteɪniəm] титан
 U — uranium [juˈreɪniəm] уран
 W — wolfram [ˈwʊlfrəm] = tungsten [ˈtʌŋstən] вольфрам
 Zn — zinc [zɪŋk] цинк
 Zr — zirconium [zɜːˈkəʊniəm] цирконий

Appendix 3

Keys and Answers

Physics Problems for Fun

Unit I

1. After reaching the ground, the lightning current spreads out and runs partially horizontal. If a cow stands, an appreciable amount of the ground current enters the front legs and exits from the rear legs, electrocuting the cow. If you are caught outside during a thunderstorm, you should not lie down. If a strike hits nearby, the resulting electrical potential between your head and your feet may draw enough of the ground currents to kill you. Since you also should not stand up, the best position is to squat. That way you keep your head low while minimizing the contact area with the ground. With minimal contact area, the possible electrical potential from one side of the contact area to the other is least, and you will draw the least ground current.

2. The right-handed boomerang is thrown in a vertical plane so that it spins about a horizontal axis. Since it is an air-foil, there is a sideways "lift" on it, the lift being larger on the top half than on the bottom half, because the top half is turning in the same direction that the boomerang is traveling, whereas the bottom half is turning in the opposite direction. Therefore, there is a torque attempting to tilt the boomerang, but instead of tilting, the boomerang veers to the left and remains vertical. Sufficient veering causes the boomerang to turn full circle in its flight.

3. The oscillations of the balance wheel are near the resonant frequency of the swinging of the pocket watch. If the watch case oscillates with a frequency somewhat greater than the balance wheel, then the case and balance wheel swing in opposite phase, and the watch gains time. The opposite result occurs for a watch case having a lower frequency.

Unit II

1. Increased heat flow by the blood to the skin surface and increased sweating carry off most of the additional heat. But these can lead to several minor and also serious disorders. The increased blood flow to the skin may decrease the flow to the brain, causing faintness, especially when a person suddenly stands. Nausea, cramps, and circulatory failure can result from the salt depletion caused by the increased sweating. If about 2% of the body's water weight is sweated away, the person becomes very thirsty. If the losses are about 7%, the circulation can fail, with the person quickly dying. Overheating in the body results in the same symptoms, leading to collapse and possibly death.

2. If the wall is such that you cannot just drive around it, and assuming ideal conditions of brakes, road conditions, and so on, and ignoring any considerations of how people in the car might get hurt for impacts on certain sides of the car, then calculations indicate that you should steer directly for the wall and attempt to stop as quickly as possible. Twice as much force would be needed to turn the car in a circular arc in attempting to avoid the wall as would be needed to stop the car in a straight stop.

3. A sudden warming can melt some of the snow to provide enough water to lubricate the sliding of the remaining snow. A sudden cooling can be equally dangerous. At sunset, for example, the cooling can freeze liquid water already present, and the resulting 11% expansion by the water can trigger an avalanche.

4. The tube connecting the bird's head and base extends into the base. There is a liquid in the base that is deep enough to submerge the lower end of the tube. Above the liquid, both in the base and in the rest of the tube and the head, is the vapor from that liquid. Those two pockets of vapor are therefore not connected. As water evaporates from the felt on the head, the head and the vapor inside the head cool, lowering the pressure of the vapor in the head. Then there is greater pressure in the vapor pocket in the base than in the head and liquid is pushed slowly up the tube toward the head. Eventually this makes the bird so unstable that it tilts forward and dunks its head in the water glass. Just when the bird is horizontal, those two pockets of vapor are connected and equalize in pressure. With equal pressures, there is nothing to force the liquid up the tube and the instability is removed. During the jostling of the dunk, the bird rights itself, and then the whole cycle begins again.

Unit III

1. A stone that skips on sand usually has its trailing edge strike first, causing a torque that produces both the short hop and a rotation to bring the leading edge down for contact. After the front end strikes, the stone takes a long jump. The short hops appear to be missing from the skipping over water. Again the trailing edge hits first, but now the stone planes along the water, titling back as a crest develops in front of it, and then finally takes a long jump. You might try high-speed photography to analyze the forces and torques more carefully.

2. Archimedes' feat was reconstructed in 1973 by a Greek engineer who had 70 flat mirrors (each about 5 ft by 3 ft) held by soldiers who focused the sun's image on a rowboat about 160 ft off shore. Once the soldiers properly aimed their mirrors, the rowboat began to burn within a few seconds, eventually being engulfed in flames. Arthur C. Clarke independently used the idea in one of his science fiction short stories ("A Slight Case of Sunstroke"). The home-town spectators at a soccer match were each given a shiny souvenir program. When one of the referees called an unpopular decision in favour of a visiting team, the home-town spectators burned the referee to a crisp by directing the sunlight on him with their programs.

Unit IV

1. In continuously reflecting from the walls of the dome, the sound waves are reinforced in a narrow belt around the perimeter of the wall. If the listener stands inside this belt, he or she can hear the whisper. Further from the wall, however, the reinforcement decreases and the whisper becomes inaudible. A whisper works better because it has more of the high frequency sounds than does normal talking, and the audible belt is wider with higher frequencies.

2. The speed of sound in air increases as the air temperature increases. Thus, as a sound wave reaches the increasingly warmer air in the stratosphere, the higher portion of the wave will travel faster than the lower portion, causing the wave path to bend over and eventually turn downward. Sound will be heard where it reaches the ground. In the meantime, some direct sound from the source will travel horizontally until it is scattered or absorbed by the objects on the ground. Between the outer region of this horizontal propagation and the region where sound is returned from the stratosphere, there is a region in which sound from the source is not heard. If the sound returned from the

stratosphere is reflected by the ground sufficiently well that it can return to the stratosphere, it can be bent over and returned to the ground once again to give yet another region of sound.

3. Part of the energy from the particle and electromagnetic radiation emitted by the initial burst is absorbed by the air in the immediate vicinity of the burst. Those air molecules are highly excited or ionized, and the resulting deexcitation and recombination yields visible light. About half of the initial burst energy is released as mechanical energy (and develops a shock wave), about a third emerges as electromagnetic energy (infrared, visible, UV, X rays, and gamma rays) and the rest is given to particles. The shock wave rapidly compresses the air, heating it to incandescence. The temperature of the fireball's surface about 10^{-4} s after burst can be 3×10^5 °K or greater. The fireball expands and cools, and eventually the shock wave breaks away from the ball and thus no longer causes incandescence.

Unit II

Answers to problems

2 — closest approach is 10 *m*

3 — 1720 *m*

4 — (a) $9.7 \text{ m}\cdot\text{s}^{-2}$

(b) $30 \text{ m}\cdot\text{s}^{-2}$

(c) 60 *m* should have been 20 *m*

Unit III, Reading III, ex. 2

The paragraphs begin with the words:

“In our day, ...” (2)

“This shows...” (3)

“Using astronomical...” (4)

“Copernicus was very careful...” (5)

“At the beginning, ...” (6)

Unit V

Key to the text about DESY

1 — d; 2 — c; 3 — a; 4 — b; 5 — e.

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Recommended Internet Resources

1. video.about.com/physics/What-is-Physics.htm
2. video.about.com/physics/Physics-Terms-and-Phrases-to-Know.htm
3. video.about.com/physics/What-Are-the-Main-Fields-of-Physics.htm
4. video.about.com/physics/The-Grand-Ideas-of-Science.htm
5. video.about.com/physics/What-Are-the-Major-Laws-of-Physics.htm
6. video.about.com/physics/Quick-Tip-Newton's-First-Law-of-Motion.htm
7. video.about.com/physics/Quick-Tip-Newton's-Second-Law-of-Motion.htm
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