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# BASICS OF PHYSICS

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ РФ

НОВОСИБИРСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ

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# BASICS OF PHYSICS

Основы физики

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Учебник английского языка предназначен для студентов 3 курса физического факультета НГУ и разработан в соответствии с требованиями основной образовательной программы подготовки студентов по направлению Физика, квалификация «бакалавр» с учетом компетентностного подхода к иноязычному образованию и развитию межкультурной коммуникации. Учебник составлен в целях совершенствования навыков чтения и перевода научной литературы на английском языке; написания рецензий и научных статей; умения вести беседу на научные темы. Учебник состоит из трех модулей, каждый из которых посвящен одной из тем по физике: атомы и материя, пространство и время, материя и движение; практикума для самостоятельной работы студента, краткого грамматического справочника и библиографии.

CONTENTS

# UNIT ONE: ATOM AND MATTER

## Part I "STANDARD MODEL"

"The creating element in the mind of man emerges in as mysterious a fashion as those elementary particles which leap into momentary existence in great cyclotrons, only to vanish again like infinitesimal ghosts"

Sir Arthur Eddington, 1928

LEAD-IN

**1. Discuss these questions with your partner.**

What is an atom?

What is smaller than an atom?

What happens if you split an atom?

VOCABULARY

**2. Match these words with their definitions.**

| | | | |
|---|---|---|---|
| 1. | subatomic | a | part of an atom which has no charge |
| 2. | electron | b | two or more particles |
| 3. | neutron | c | smaller than an atom |
| 4. | molecule | d | part of an atom that has a negative charge |
| 5. | proton | e | a theory developed by physicists to explain the atom |
| 6. | quantum mechanics | f | part of an atom which has a positive charge |
| 7. | carbon | g | pulled together |
| 8. | attracted | h | a chemical element |
| 9. | helium | I | a chemical element that is lighter than air |
| 10. | universe | j | the whole cosmos |

**3. Read and complete the text using the words below.**

STANDARD MODEL

[1] All matter around us is made of elementary particles, the building blocks of matter. These particles occur in two basic types: quarks and leptons. Each group consists of six particles, which are related in pairs, or 1)… . The lightest and most stable particles make up the first generation, whereas the heavier and less stable particles belong to the second and third generations. All stable matter in the universe is made from particles that belong to the first generation, and heavier particles quickly decay to the next most stable level. The six quarks are paired in the three generations-the up quark and down (or beauty) quark; next come 'strange' and 'charm' quarks; finally, the 'top and bottom' quarks are the heaviest pair. Quarks also come in three different "colors": red, blue and green. Just as electrons and protons carry "color charge", which is 2)… when quarks change from one type to another. Color charge has nothing to do with the visible colors of light- it is just an arbitrary way of naming the quantum properties of quarks. Just as electric charges produce a force, so color charges (quarks) can exert forces on one another. Color force gets 3)… the further the quarks are apart, so they stick together as if held by an invisible elastic band. Because the color force field tie is so strong, quarks cannot exist on their own and must always be locked together in combinations that are color neutral overall (exhibiting no color charge).

[2] The second class of particles, the leptons, are related to and include 4)… .(A) Again there are three generations with increasing masses: electrons, muons and taus. 5)… are 200 times heavier than an electron and taus 3700 times. (B)Leptons all have single 6)… charge. (C)They also have an associated particle called a neutrino that has no charge.(D) Neutrinos have almost no mass and do not interact much with anything. They can travel right through the Earth without noticing, so are difficult to catch. All leptons have antiparticles.

[3] Fundamental forces are mediated by the exchange of particles. There are four fundamental forces at work in universe: the strong force, the weak force, the electromagnetic force, the gravitation force. They work over different ranges and have different strengths. Gravity is the weakest but it has an infinite range. The electromagnetic force also has 7)… range but it is many times stronger than gravity. The weak and strong forces are effective only over a short range and dominate only at the level of 8)… particles. Despite its name, the weak force is much stronger than gravity but it is indeed the weakest of the other three. The strong force is the strongest of all four fundamental interactions.

[4] Three of the fundamental forces result from the exchange of force-carrier particles, which belong to a broader group called 9)… . Particles of matter transfer discrete amounts of energy by exchanging bosons with each other. Each fundamental force has its own corresponding boson- the strong force is carried by the 10)… , the electromagnetic force is carried by the photon and the W and the Z bosons are responsible for the weak force.

[5] The Standard model includes the electromagnetic, strong and weak forces and all their carrier particles, and explains well how these forces act on all of the matter particles. However, the most familiar force in our everyday lives, 11)… , is not part of the Standard model, as fitting gravity comfortably into this framework has proved to be a difficult challenge.

[6] How do we know about these subatomic particles? Particle accelerators use giant magnets to accelerate particles to extremely high speeds and smash those particle beams either into a target or into another oppositely directed beam. At 12)… speeds, the particles break apart a little and the lightest generations of particles are released. Because mass means energy, you need a higher particle beam to release the heavier generations of particles.

[7] 1__ In the magnetic field, positive charged particles swerve one way and negative ones the other. 2__ The particles produced in the atom smashers then need to be identified and particle physicists do this by photographing their 13)… as they pass through a magnetic field. 3__ By mapping their characteristics in the detector, and comparing them with what they expect from their theories, particle physicists can tell what each particle is. 4__ The mass of the particle also dictates how fast it shoots through the detector and how much its path is curved by the magnetic field. 5__ So light particles barely curve and heavier particles may even spiral into loops.

a. tracks
b. electrons
c. muons
d. subatomic
e. stronger
f. modest
g. negative
h. generations
i. bosons
j. conversed
k. gravity
l. infinite
m. gluons

**4. Arrange the sentences of the last paragraph in the right order.**

**5. Read the text again and find the words that mean the same as the following definitions.**

a. a property of something that dictates its potential for change;
b. a fundamental force through which masses attract one another;
c. a means of transmitting a force at a distance;
d. light manifesting as a particle;
e. physical substance in general that everything in the world consists of;
f. a property that is equivalent to the number of atoms or amount of energy that something contains;
g. to be destroyed gradually by natural processes;

h. to move in continuous circles, going upwards or downwards;
i. a lift, pull or push, causing the motion of something to change;
j. a fundamental particle, three of which combine to make up protons and neutrons.

**6. In pairs, discuss and write definitions for the following terms from the text. Use a dictionary to help you.**

| | | |
|---|---|---|
| stable | dominate | release |
| charge | discrete | beam |
| infinitesimal | magnet | curve (n) |

**7. Fill the gaps with the new words in the correct form:**

***decay, boson, subatomic, mass, energy, muons, stable, magnet, curve, release, gravity***

**PART A**

a. The _____ of a substance doesn't change with temperature or location in space.
b. The_____ of light is transformed directly into electricity in photocells.
c. Ernest Rutherford was the first to suggest that radioactivity was the result of atomic _____.
d. Although simple harmonic motion is predictable and _____ , adding even small extra forces can destabilize it and may precipitate catastrophe.
e. Not all_____ particles are charged, however.
f. Hold two_____ close to one another, you can feel them repel.
g. Every body has a centre of_____.
h. _____ are much heavier than electrons but lighter than taus.
i. The ball_____ through the air.
j. Intense heat is_____ in the reaction.
k. The Higgs_____ is called 'God particle'.

**PART B**

***charge, infinitesimal, dominate, discrete, beam, spiral (v), track***

a. If the gap is small compared with the distance between the waves then the rounded edges _____ the pattern and the transmitted wave may look almost semi-circular.
b. Using together Heiesenberg's matrix mechanics and Schrodinger's wave equation was fundamentally difficult because one was_____ and the other continuous.
c. Turn the quarks into antiquarks by flipping their_____, and you've made an antineutron.
d. On some surfaces the _____ of the particles became unstable, and they fell off the edge.
e. During the experiment the_____ traces of poison were found.
f. The time the _____ takes to travel to the Moon and back can be used to calculate the distance to the Moon.
g. The plane_____ down the ground.

**8. Look at the four lettered spaces in the text (A),(B),(C),(D) that indicate where the following sentence can be added to the passage. Where would this sentence best fit?**

*The biggest difference between leptons and quarks is that leptons don't have color charges, and therefore aren't affected by the strong force.*

**9. Which of the sentences below expresses the summary of the text:**

- Standard Model is a quite table of all elementary particles;
- Standard Model is an attempt to create a unified theory;
- Standard Model is a theoretical structure of interactions of all elementary particles.

**10. Choose the phrase which could replace parts of these phrases.**

**A.** Color charge has nothing to do

1. Isn't connected with colors of light;
2. Doesn't have anything in common with colors of light;
3. Isn't carried by light;

**B.** Fundamental forces are mediated by

1. are influenced;
2. are annihilated;
3. are balanced;

**C.** fitting gravity comfortably into this framework

1. including gravity into Standard Model;
2. adding gravity to Standard Model;
3. making gravity suitable for the requirements of Standard Model.

**11. For each set find one word mentioned in the text that will fit all sentences.**

A.

a) The anti-electron has its own name, position. It's a_____of common knowledge.
b) _____is made of atoms and atoms are made of electrons and quarks exchanging photons and gluons.
c) No_____ when particle and antiparticle meet, their motion in complex time cancels out and they combine into photon which has zero movement in time.

B.

a) The fusion process is in _____of powering the stars.

b) The biggest difference between lepton and quarks is that leptons don't have color _____.

c) The battery is on _____.

C.

a) The _____of the transmitter of the next generation may increase by 20 per cent.

b) The movement of this asteroid is still beyond the _____of vision.

c) Since W and Z bosons can't move very far their _____of the weak force is very small.

**12. Use the words given in brackets to form a word that fits in the gaps.**

1) The neutron is one of the two kinds of elementary particles of which all _____ (nucleus) consist.
2) The other kind of particle and neutrons and protons are often called by the _____ (collect) name nucleons.
3) Neutrons and protons _____ (different), however, protons are_____ (charge) while neutrons have no charge at all.
4) Ordinary hydrogen gas is _____ (atom).
5) A plasma may be _____ (part) ionized, with only a fraction of the molecules ionized and the remainder _____ (electric) neutral.
6) Antimatter production is_____ (current) very limited, but has been growing at a nearly _____ (geometry) rate since the discoveries of the first_____ (proton) in 1955.
7) _____ (store) is another problem as antiprotons repel against each other.
8) Plasma _____ (oscillate) in the charged cloud of antiprotons can cause _____ (stable).
9) It is hoped that antimatter could be used as a fuel for _____ (planet) travel or _____ (star) travel.

10) The story of quantum physics has as many twists and turns as it has strange _____ (phenomenon).
11) At large distances there is an _____ (attract), but at closer distances there is a_____ (repel).
12) This interest is due in part to the wide _____ (occur) of the plasma state in astrophysical studies and in part to the various research programs in controlled thermonuclear reactions.

**13. Read the sentences and mark T (true) or F (false).**

1. The strong force causes nuclear reaction that has let the sun shine for billions of years.
2. Photons mediate the electromagnetic force between electrically charged particles.
3. Neutrinos are very light and hardly ever interact with ordinary matter.
4. Protons and neutrons are both made from quarks.
5. The weak force binds atomic nuclei together, making them stable.
6. The neutron consists of two up and one down quarks.

**14. Complete each sentence by matching it with the appropriate ending.**

| | |
|---|---|
| 1) The Standard model of particle physics is a theory which describes | a) no electric charge; |
| 2) Each quark carries | b) at the level of subatomic particles; |
| 3) Leptons do not carry | c) any of the three color charges; |
| 4) The up-type quarks participate in | d) bosons with each other; |
| 5) The down-type quarks carry | e) any color charge- they are color neutral; |
| 6) Particles of matter exchange | f) electromagnetic interactions; |
| 7) The weak and strong forces are effective only | g) three of the four known fundamental interactions between elementary particles that make up all matter. |

**15. Choose the correct answer A, B, or C from the list below.**

In the early 20$^{th}$ century physicists knew that matter was 1)… of protons, neutrons and electrons. 2)… had described how, due to quantum theory, electrons arranged themselves in a series of 3)… around nucleus, like the orbits of planets around the Sun. The 4)… of the nucleus were even stranger. Despite their repelling positive charges, nuclei could host tens of protons alongside neutrons 5)… into a tiny hard kernel, bound by the precise strong nuclear force. But as more was learned from radioactivity about how nuclei broke apart or joined together, it became clear that more 6)… needed to be explained.

First, the burning of hydrogen into 7)… in the Sun, via fusion, implicates another particle, neutrino, which transforms 8)… into neutrons. In 1930, the neutrino's existence was inferred to explain the decay of a neutron into a proton and electron-9)… radioactive decay. The neutrino itself was not discovered until 1956, having virtually no 10)… . So, even in the 1930s there were many loose ends. But in the 1940s and 50s other particles were sought and the collection grew.

| | | | |
|---|---|---|---|
| 1. | A discovered | B consisted | C made up |
| 2. | A Newton | B Niels Bohr | C Dalton |
| 3. | A groups | B shells | C grid |
| 4. | A properties | B composition | C mass |
| 5. | A squeezed | B pushed | C compressed |
| 6. | A phenomena | B events | C facts |
| 7. | A oxygen | B helium | C deuterium |
| 8. | A protons | B electrons | C taus |
| 9. | A alpha | B beta | C gamma |

10. A mass B electric charge C color charge

**16.Read the text below and think of the word which best fits each space. Use only one word in each space. There is an example at the beginning. (0)**

**Example:(0) was**

**Slow motion**

Higg's big idea (0) to think of these force carriers as being slowed (1) passage through a background force field. Now called the Higg's field, (2) also operates by transfer (3) bosons called Higg's bosons. Imagine dropping a bead (4) a glass .It will take longer to drop to the bottom (5) the glass is filled (6) water than if it is empty and filled with air. It is as if the bead is (7) massive when in water- it takes longer for gravity to pull it ( 8) the liquid. The bead may (9) slowed even more if dropped into a glass of syrup, taking a while to sink. The Higg's field acts in a similar way, just (10) a viscous liquid. The Higgs force slows down the other force-carrying particles, effectively giving (11) a mass. It acts more strongly on the W and Z bosons (12) on photons, making them appear heavier.

SPEAKING

**17. Answer the following questions.**

1. What is the Standard model?
2. What groups does it consist of? Can you describe them?
3. How do the fundamental forces differ from each other?
4. What ways did the scientists use to detect subatomic particles?
5. Why isn't gravity included in Standard model?

**18. Complete these sentences with information that reflects your personal views.**

1. The Standard model is a successful theory of particle physics…
2. The biggest success of the Standard model is…
3. The biggest failure of the Standard model is…

**19. In pairs, role-play conversations in which a physicist explains the main ideas of the Standard model to a layperson.**

**20. In pairs or small groups, look for information on one of the topics from the list below and prepare an oral report.**

- How will the discovery of Higgs boson affect the Standard model?
- Do all the scientists support the Standard model?
- Is it possible to create a Unified theory?

**21. Test yourself.**

1) What are the states of matter? Describe five properties for each of them.
2) Draw out what the particles look like in a solid, a liquid and a gas.
3) Give the names of six changes of state, and say which state they go from and to.
4) Explain how gases exert a pressure on the insides of a container.
5) What happens to the pressure of a gas if the volume of the gas is decreased?
6) Explain what diffusion is. What's it a bit like doing?
7) What is a compound? How is a compound different from a mixture?
8) Is it easy to split a compound back up into its original elements?

9) What is an alloy?
10) Why is diamond different from most non-metals? What is unusual about graphite?

LISTENING

**22. Listen to 'CERN the Standard Model of Particle Physics' and choose the right answer.**

1) The objective of particle physicists is :
   a) To understand the basic structure and laws of nature;
   b) To create a unified theory of the universe's structure;
   c) To discover all elementary particles;
2) At first scientists supposed that an atom has:
   a) A nucleus and electrons;
   b) Protons, neutrons and electrons;
   c) Leptons and quarks;
3) The scientists found many new elementary particles:
   a) At the beginning of the $20^{th}$ century;
   b) At the end of the $19^{th}$ century;
   c) At the end of the $20^{th}$ century;
4) All particles were organized according to their:
   a) Spin;
   b) Mass and an electrical charge;
   c) Properties;
5) The weak force explains:
   a) The energy of the nucleus;
   b) Radioactive gamma decay;
   c) The energy of the Sun and radioactive beta decay;
6) Quarks are glued together by gluons in:
   a) Protons;
   b) Neutrons;
   c) Protons and neutrons;
7) Beyond the Standard model there are many questions to be answered such as:
   a) Superconductivity and wave-particle duality;
   b) Supersymmetry and extra dimensions;
   c) Black holes and antimatter.

**Funny Science Jokes**

1. What's the difference between a quantum mechanic and an auto mechanic? The quantum mechanic can get inside without opening the door.

2. Who solves mysteries involving electricity? Sherlock Ohms.

DESCRIBING GRAPHS

**23. Look at the table, graph or figure and describe it.**

To understand and describe graphs and tables you should understand the following details:

*What is the information or data in the graph or table about?*

*What are the units of measurement used?*

*What are the area (place) involved?*

*What is the purpose of the graph or table?*

*What is the time-scale involved?*

This is the list of some introductory expressions which can be useful to begin the description of the graph or table with:

***The graph/ table shows / indicates/illustrates/ reveals/represents;***

***It is clear from the graph/table;***

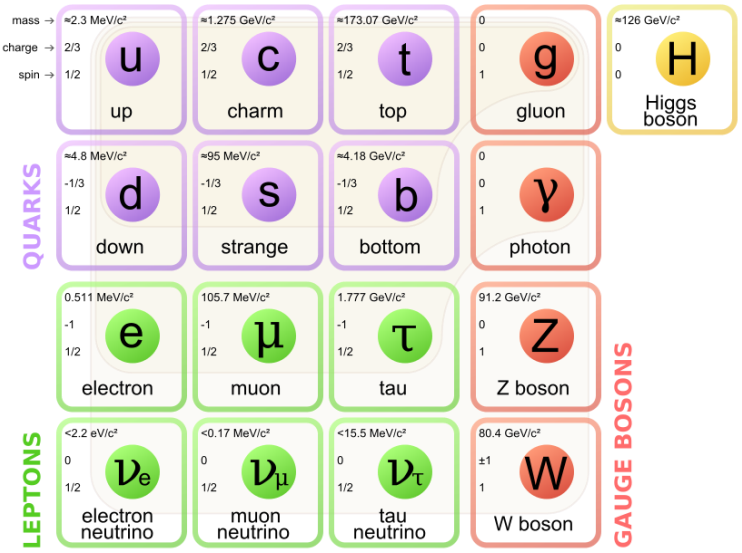
***It can be seen from the graph/table;***

***As the graph/table shows;***

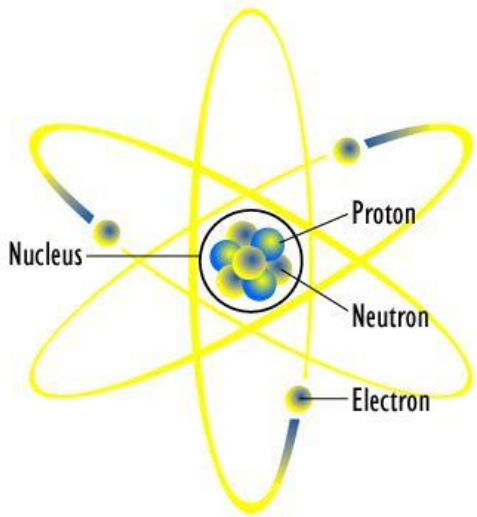
***From the graph/ table it is clear***

Notice that it is best to avoid using personal pronouns. Instead of saying *We can see from the graph* it is better to use the passive or impersonal constructions, as above.

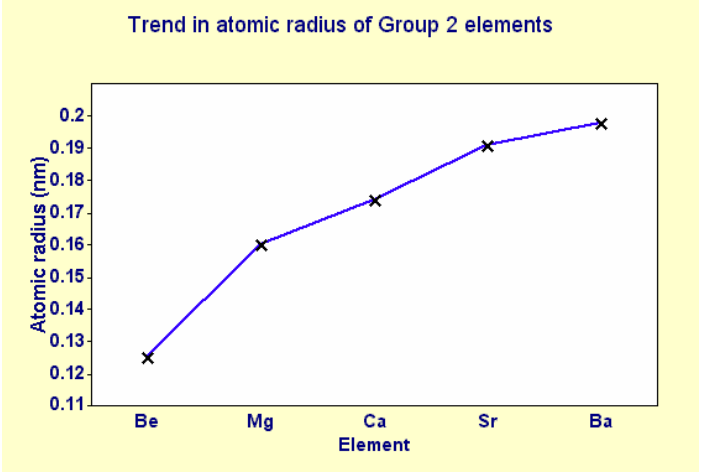
**A.**




**B.**




**C.**




WRITING

**24. Translate the paragraph int o Russian.**

Quarks and the Strong Force

Quarks are half of the fundamental matter particles in the Universe. According to the Standard model of particle physics, each elementary particle comes with an opposite antiparticle, so there are six quarks

and also six anti-quarks. Quarks are never found in nature as individual, isolated particles because they bind very strongly to each other via the strong force.

The strong force is one of the four fundamental forces of physics. Like the more familiar electric force, it has positive and negative charges. Unlike the electric force, there are three of them rather than one. Physicists find it convenient to think of them as if they were three primary colors – one red, one green, one blue – because the way they work is just like the RBG color system.

**25. Translate the paragraph into English.**

Слабое взаимодействие

Слабое взаимодействие введено в физику элементарных частиц для объяснения явления бета-распада ядра. Слабое взаимодействие проявляется на расстояниях значительно меньших радиуса ядра. В слабом взаимодействии участвуют лептоны, кварки и частицы нейтрино. Слабое взаимодействие слабее электромагнитного и сильнее гравитационного. Слабое взаимодействие позволяет лептонам и кваркам превращаться в античастицы, то есть обмениваться квантовыми числами, энергией, массой, электрическими зарядами. Переносчиками слабого взаимодействия являются виртуальные W- и Z - бозоны. Слабое взаимодействие нарушает все виды симметрии, позволяет кваркам одного аромата превращаться в кварки другого аромата, заряженным лептонам превращаться в нейтрино.

MINI GRAMMAR

ARTICLES

Articles can be difficult to use correctly: the rules are many and complex. Here are some of the most important rules.

ZERO ARTICLE

You don't use articles with proper nouns such as places, people and companies.

*John Smith had a job with Microsoft but now he's moved to IBM.*

Exceptions are when the article is part of a name (the BBC, the Beatles)

The indefinite article means 'one', so you don't use it with plurals or uncountable nouns.

*There are plenty of ideas. The love of money is the root of all devil.*

In English, most abstract concepts are uncountable:

*After a few years of hard work…*

INDEFINITE ARTICLE: INTRODUCING/ CATEGORISING

When you first mention new people, places or objects etc., the most normal thing to do is to introduce them by saying what category they belong to. You use the indefinite article to show that this is what you are doing.

*There is a new report from IBM.*

DEFINITE ARTICLE: REFERRING/IDENTIFYING

When you identify something or refer to a specific thing, you use the definite article. This often happens for one of these two reasons.

Back reference:

*THERE was a young lady of Niger*
*Who smiled as she rode on a Tiger;*
*They came back from the ride*
*With the lady inside,*
*And the smile on the face of the Tiger.*

(The last three lines of the poem refer to things introduced in the first two)

Shared knowledge:

*You could use the devices and the results of the experiments in our lab.*

Back reference and shared knowledge can combine.

*He took a photograph. The click of the camera woke the man up.*

In general statements in English you don't usually use the definite article with plural or uncountable nouns.

Here are some general rules for using articles:

- Don't use articles (a/an, the) with most proper nouns.
- Don't use the indefinite article (a/an) with plurals or uncountable nouns.
- Use the indefinite article (a/an) to introduce new information.
- Use the definite article (the) to refer to specific things which have already been mentioned.
- Use the definite article (the) to refer to things that you know the listener or hearer can identify.

**26. Read, translate the sentences, and explain the use of articles.**

1) The sun rotates on its axis just as the earth does, from west to east, but takes longer to complete a rotation.
2) Nature is a slave to periodicity. The seasons, the tides, darkness and light and of others are periodic or approximately so.
3) The close agreement of the six observations is unlikely to be a coincidence.
4) When an organization grows, both it and its procedures change.
5) A production system is composed of three elements: data, a set of rules, and an interpreter.
6) Assumptions have to be made.
7) An example is shown in Fig. 3
8) The difference between the two factors is due to different methods of estimating.
9) Several cases were studied and satisfactory results have been obtained.
10) In this case an analytical solution is unattainable.

APPENDIX

The names of the elements in English

| | | |
|---|---|---|
| 1 - H - Hydrogen | 5 - B - Boron | 9 - F - Fluorine |
| 2 - He - Helium | 6 - C - Carbon | 10 - Ne - Neon |
| 3 - Li - Lithium | 7 - N - Nitrogen | 11 - Na - Sodium |
| 4 - Be - Beryllium | 8 - O - Oxygen | 12 - Mg - Magnesium |

13 - Al - Aluminum, Aluminium
14 - Si - Silicon
15 - P - Phosphorus
16 - S - Sulfur
17 - Cl - Chlorine
18 - Ar - Argon
19 - K - Potassium
20 - Ca - Calcium
21 - Sc - Scandium
22 - Ti - Titanium
23 - V - Vanadium
24 - Cr - Chromium
25 - Mn - Manganese
26 - Fe - Iron
27 - Co - Cobalt
28 - Ni - Nickel
29 - Cu - Copper
30 - Zn - Zinc
31 - Ga - Gallium
32 - Ge - Germanium
33 - As - Arsenic
34 - Se - Selenium
35 - Br - Bromine
36 - Kr - Krypton
37 - Rb - Rubidium
38 - Sr - Strontium
39 - Y - Yttrium
40 - Zr - Zirconium
41 - Nb - Niobium
42 - Mo - Molybdenum
43 - Tc - Technetium
44 - Ru - Ruthenium
45 - Rh - Rhodium
46 - Pd - Palladium
47 - Ag - Silver
48 - Cd - Cadmium
49 - In - Indium
50 - Sn - Tin
51 - Sb - Antimony
52 - Te - Tellurium
53 - I - Iodine
54 - Xe - Xenon
55 - Cs - Cesium
56 - Ba - Barium
57 - La - Lanthanum
58 - Ce - Cerium
59 - Pr - Praseodymium
60 - Nd - Neodymium
61 - Pm - Promethium
62 - Sm - Samarium
63 - Eu - Europium
64 - Gd - Gadolinium
65 - Tb - Terbium
66 - Dy - Dysprosium
67 - Ho - Holmium
68 - Er - Erbium
69 - Tm - Thulium
70 - Yb - Ytterbium
71 - Lu - Lutetium
72 - Hf - Hafnium
73 - Ta - Tantalum
74 - W - Tungsten
75 - Re - Rhenium
76 - Os - Osmium
77 - Ir - Iridium
78 - Pt - Platinum
79 - Au - Gold
80 - Hg - Mercury
81 - Tl - Thallium
82 - Pb - Lead
83 - Bi - Bismuth
84 - Po - Polonium
85 - At - Astatine
86 - Rn - Radon
87 - Fr - Francium
88 - Ra - Radium
89 - Ac - Actinium
90 - Th - Thorium
91 - Pa - Protactinium
92 - U - Uranium
93 - Np - Neptunium
94 - Pu - Plutonium
95 - Am - Americium
96 - Cm - Curium
97 - Bk - Berkelium
98 - Cf - Californium
99 - Es - Einsteinium
100 - Fm - Fermium
101 - Md - Mendelevium
102 - No - Nobelium
103 - Lr - Lawrencium
104 - Rf - Rutherfordium
105 - Db - Dubnium
106 - Sg - Seaborgium
107 - Bh - Bohrium
108 - Hs - Hassium
109 - Mt - Meitnerium
110 - Ds - Darmstadtium
111 - Rg - Roentgenium
112 - Cn - Copernicium
113 - Uut - Ununtrium
114 - Fl - Flerovium
115 - Uup - Ununpentium
116 - Lv - Livermorium
117 - Uus - Ununseptium
118 - Uuo - Ununoctium

# Part II "ANTIMATTER"

*'For every one billion particles of antimatter there were one billion and one particles of matter. And when the mutual annihilation was complete, one billionth remained - and that's our present universe,'*

Albert Einstein, 1879-1955

LEAD-IN

**1. Discuss these questions with your partner.**

What is antimatter?

Where is all antimatter?

What can happen when matter and antimatter come into contact?

**2. Read the article and fill in the missing parts of sentences. One of them is extra.**

a) exist in only one form;

b) the photon and gluon look the same;

c) whether anti-hydrogen behaves;

d) a vast amount of matter and antimatter;

e) positive energy was expected;

f) to reveal the antiproton;

g) which are reversed;

h) the track of a positively charged particle.

THE MYSTERY OF ANTIMATTER

[1] Fictional spaceships are often powered by 'antimatter drives', yet antimatter itself is real and has even been made artificially on Earth. The history of antimatter's discovery began in 1928 when British physicist Paul Dirac saw that his equation for the electron offered the possibility that electrons could have negative as well as positive energy. Dirac had two ways of solving his problem: [1__], associated with a normal electron, but negative energy made no sense. But rather than ignore this confusing term, Dirac suggested that such particles might actually exist. This complementary state of matter is antimatter.

[2] The hunt for antimatter began quickly. In 1932 Carl Anderson confirmed the existence of positrons experimentally. He was following the tracks of showers of particles produced by cosmic rays. He saw [2__] with the electron's mass, positron. So antimatter was no longer just an abstract idea but real.

[3] It took another two decades before the next antiparticle, the antiproton, was detected. Physicists built new particle-accelerating machines that used magnetic fields to increase the speeds of particles travelling through them. Such powerful beams of speeding protons produced enough energy [3__] in 1955. Soon afterwards, the antineutron was found.

[4] With the antimatter equivalent building blocks in place, was it possible to build an anti-atom, or at least an anti-nucleus? The answer was yes. A heavy hydrogen (deuterium) anti-nucleus (an anti-deuterium), containing an antiproton and antineutron, was created by scientists at CERN in Europe and Brookhaven Laboratory in America. Tagging on a positron to an antiproton to make a hydrogen anti-atom (anti-hydrogen) took a little longer, but it was achieved in 1995. Today experimenters are testing [4__] in the same way as normal hydrogen.

[5] On Earth, physicists can create antimatter in particle accelerators. When the beams of particles meet, they annihilate each other in a flash of pure energy. Mass is converted to energy according to Einstein's $E=mc^2$. So if

you met your antimatter twin, it might not be such a good idea to throw arms around them.(A) If antimatter were spread across the universe, these annihilation episodes would be occurring all the time. (B) Matter and antimatter would gradually destroy each other in little explosions, mopping each other up.(C) In fact normal matter is the only widespread form of particle we see, by a very large margin.

[6] Like all mirror images, particles and their antiparticles are related by different kinds of symmetry. One is time. Because of their negative energy, antiparticles are equivalent mathematically to normal particles moving backwards in time. So a positron can be thought of an electron travelling from future to past. The next symmetry involves charges and other quantum properties, [5__], and is known as 'charge conjugation'. A third symmetry regards motion through space. Returning to Mach's principle, motions are generally unaffected if we change the direction of coordinates marking out the grid of space. A particle moving left to right looks the same as one moving right to left, or is unchanged whether spinning clockwise or anticlockwise. This 'parity' symmetry is true of most particles, but there are a few for which it does not always hold. Neutrinos [6__], as a left-handed neutrino, spinning one direction; there is no such thing as a right-handed neutrino. The converse is true for antineutrinos which are all right-handed. So parity symmetry can sometimes be broken, although a combination of charge conjugation and parity is conserved, called charge-parity or CP symmetry for short.

[7] Just as chemists find that some molecules prefer to exist in one version, as a left-handed or right-handed structure, it is a major puzzle why the universe contains mostly matter and not antimatter. A tiny fraction – less than 0.01% - of the stuff in the universe is made of antimatter. But the universe also contains forms of energy, including a lot of photons. So it is possible that [7__] was created in the big bang, but then most of it annihilated shortly after. Only the tip of the iceberg now remains. A minuscule imbalance in favor of matter would be enough to explain its dominance now. To do this, only 1 in every $10^{10}$ matter particles needed to survive a split second after the big bang, the remainder being annihilated. The leftover matter was likely preserved via a slight asymmetry from CP symmetry violation.

**3. Look at three lettered spaces in the text (A),(B),(C) that indicate where the following sentence can be added to the passage. Where would the sentence best fit?**

*Because we don't see this, there cannot be much antimatter around.*

**4. Read the text again and find the words that mean the same as the following definitions.**

a. Similarity under reflection or rotation or re-scaling;
b. A line of light, electric waves or particles;
c. Combination of some things;
d. Either of two numbers or letters used to fix the position of a point on a map or graph;
e. A statement showing that two amounts or values are equal;
f. The act or process of moving or the way something moves;
g. The state of being equal;
h. The rate at which sb/sth moves or travels;
i. The path or direction that sb/sth is moving in;
j. To destroy sb/sth completely.

**5. In pairs, discuss and write definitions for the following terms from the text. Use a dictionary to help you.**

| | | |
|---|---|---|
| antimatter | fraction | pure |
| imbalance | particle | affect |
| minuscule | accelerator | to reverse |
| positron | to convert | nucleus |
| | | equivalent |

**6. Read the sentences and mark T (true) or F (false).**

1. It is easy to produce antimatter in the form of anti-atoms.
2. Almost all matter observable from the Earth seems to be made of matter rather than antimatter.

3. Many different antiparticles are produced by cosmic rays.
4. An antiproton consists of one up anti-quark and two down anti-quarks.
5. Antiparticles are produced naturally in beta decay.
6. The neutron is made out of quarks, the antineutron from anti-quarks.
7. The parity symmetry is true to all particles.
8. An antiproton and a proton can form an anti-hydrogen atom .
9. Neutral particles can have antiparticles.

**7. Complete each sentence by matching it with the appropriate ending.**

1) Antiparticles bind with each other
2) Recent research by the American Astronomical Society has discovered antimatter
3) Antimatter in the form of charged particles can be contained
4) Since the antineutron is electrically neutral
5) The asymmetry of matter and antimatter in the visible universe is
6) Antiparticles are created naturally
7) Generating a single antiproton is

a) Immensely difficult and required particles accelerators and vast amount of energy;
b) One of the greatest unsolved problems in physics;
c) To form antimatter just as ordinary particles bind to form normal matter;
d) By a combination of electric and magnetic fields;
e) When high-energy particle collisions take place;
f) It can't be easily observed directly;
g) Originating above thunderstorm clouds.

**8. Use the words given below to fill in the gaps.**

***annihilate, parity, equation, symmetry, coordinates, motion, conjugation, speed***

1) A particle has even _____if it doesn't change when it is reflected from side to side or up and down.
2) Electrons and positrons may pop into existence in the vacuum of space, then _____
3) Antimatter is matter reflected in time, what is technically called a 'charge _____ transformation.
4) Velocity is _____in a particular direction.
5) The laws of planetary _____were developed by Kepler.
6) Physicists can use the _____of electromagnetism to explain the properties of the electron some distance away from the particle.
7) The Higgs boson was deduced for the purpose of breaking _____in electroweak interactions.
8) By solving Schrodinger's equation, four quantum numbers are needed to describe any particle – three spatial_____ and the fourth one, spin.

**9. Choose the right option.**

**A.** According to the text Paul Dirac…

1. Ignored the presence of negative energy;
2. Found that his equation had negative-energy solution;
3. Suggested that anti-electrons exist.

**B.** The first evidence of positrons existence…

1. was obtained with the help of particle accelerators;
2. was discovered in space;
3. was experimentally produced by Carl Anderson in his lab.

**C.** The first antiproton was discovered in…

1. 1932;
2. 1955;
3. 1952

**D.** To make an anti-hydrogen the physicists…

1. Join antiproton and antineutron;
2. Join a positron and an anti-proton;
3. Split tritium into anti-deuterium and deuterium;

**E.** When the beams of particles and antiparticles meet, they annihilate each other and…

1. Their mass is converted into energy;
2. New virtual particles appear instead;
3. They combine into photon which has zero movement in time.

**10. Choose the phrase which could replace parts of these phrases.**

**A.** was no longer

1. Was shorter;
2. Was not possible then;
3. Didn't exist

**B.** tagging on a positron to an antiproton

1. Converting a positron into an antiproton;
2. Connecting a positron and an antiproton;
3. Replacing a positron by an antiproton

**C.** to throw arms around them

1. To embrace;
2. To hit them;
3. To throw something to them

**D.** minuscule imbalance

1. Negative disproportion;
2. Great violation of balance;
3. Infinitesimal difference in the amount

**E.** dominance

1. prevalence;
2. suppression;
3. superiority

**F.** the leftover matter

1. antimatter;
2. the rest of matter;
3. the lack of matter

**11. For each set find one word mentioned in the text that will fit all sentences.**

(1)

a) Think of a_____ and multiply it by three.

b) Elements are listed in order of atomic_____.

c) The_____ of protons in the nuclei of different elements is different.

(2)

a) Students have a _____choice of courses in their final year.

b) For their studies students get a _____ access to the internet.

c) _____radicals in the body are thought to be one of the causes of diseases.

(3)

a) _____ travels more slowly than the light.

b) We arrived home safe and _____.

c) The researchers use a novel device to _____the depth of the sea.

**12. Use the words given in brackets to form a word that fits in the gaps.**

1) A _____ (replicate) of this barometer may be constructed in the laboratory.

2) Superconductors have unlimited _____ (conduct).

3) Heat reflects_____ (molecule) vibrations.

4) The _____ (solve) came from the German physicist Max Planck, who was trying to unify the physics of heat and light at the time.

5) Using Huygens' approach, the wave energy sources at the edge of the gap radiate circular ripples, making the wave look almost _____ (circle) after it has gone through.

6) To avoid_____ (confuse) with hydrogen gas itself, in 1920 Rutherford named the bare hydrogen nucleus the 'proton', after the Greek for the 'first'.

7) Each element produces a characteristic set of _____ (spectrum) lines, like a sort of musical scale in light.

8) Scientists performed some tests, showing that the_____ (nucleus) of some atoms have quantized angular momentum.

9) For something less than half a per cent of the mass of the target atom, the neutron's impact on the uranium seemed _____ (excess).

10) Niels Bohr believed that the nucleus was like a liquid drop and forces of surface tension should resist the droplet's _____ (divide), and even if it did split then the two positively charged drops of substance would repel and fly apart.

**13. For each set find one word mentioned in the text that will fit all sentences.**

(A)

1) Can you give me some_____ how to use these equations?

2) The _____ of the rods inside the tubes were covered with ice.

3) A waiter usually expects to get some_____ .

(B)

1) All results of the experiments differ in _____ .

2) What _____ of research are you going to do?

3) He was too_____ to tell you 'no'.

(C)

1) This statement doesn't make_____ .

2) A_____ of duty made outstanding scientists join against the beginning of robot soldiers production;

3) He had the _____ to turn off the device when he felt smoke in the lab.

**14. Read the text below and think of the word which best fits each space. Use only one word in each space. There is an example at the beginning.**

**Example: (0) many**

**The BANG'S IMBALANCE**

When we look out into the universe, we don't see (0) flashes of annihilating particles. The reason is that it is almost entirely made of matter- (1) than 0.01% of the stuff in the universe is made of antimatter. What caused (2) fundamental imbalance?

It could be that slightly dissimilar amounts of each (3) created in the Big Bang. Over time (4) of the particles and antiparticles have collided and mopped (5) other up but (6) few remain. If only 1 (7) every 10,000,000,000 matter particles survived, it (8) explain the proportions we see now. This (9 ) also explain the large numbers of photons and raw forms of energy that pepper the universe.

Or it could be that some quantum process in the (10) universe set a switch to favor matter over its mirror form. Perhaps (11) unusual particles were created in the fireball that predominantly to matter. Whatever the reason, thousands of physicists at the world's great particle accelerators are trying to find it (12).

SPEAKING

**15. Answer the following questions.**

1. How did Paul Dirac come to the idea of the existence of antimatter?
2. Where did the researchers get the first results in this field?
3. How did it become possible to build an anti-atom and anti-nucleus?
4. How can antimatter be built on Earth?
5. What are the consequences of meeting particles and antiparticles?
6. What kinds of symmetry are particles and antiparticles related by?
7. What does parity symmetry mean?
8. How does the author explain the dominance of matter in the universe?

**16. In pairs, role-play conversations in which a physicist explains to a layperson:**

*why the formation of matter after the Big Bang resulted in a universe consisting almost entirely of matter, rather than being a half-and half mixture of matter and antimatter.*

**17. Look at the diagram and describe it.**

The purpose of a diagram is normally to show a process, how a piece of equipment works, or an operational structure of a system. The vocabulary will mostly be closely related to the special subject being shown. There are two aspects of the language that you will require for describing most diagrams and you should make sure that you know how to use them well:

The verbs will normally be in the present tense and the passive voice.

Where a process or structure is being presented, you will need a variety of connectors showing stages or time.

Do not attempt to describe the diagram in colorful or interesting language. There is no need for adjectives or adverbs.

Avoid repetition and try to vary your language.

Do not simply use ***firstly, secondly***, etc. or ***then*** to link different stages.

Here are some other possibilities:

***In the first/second/etc. stage…***

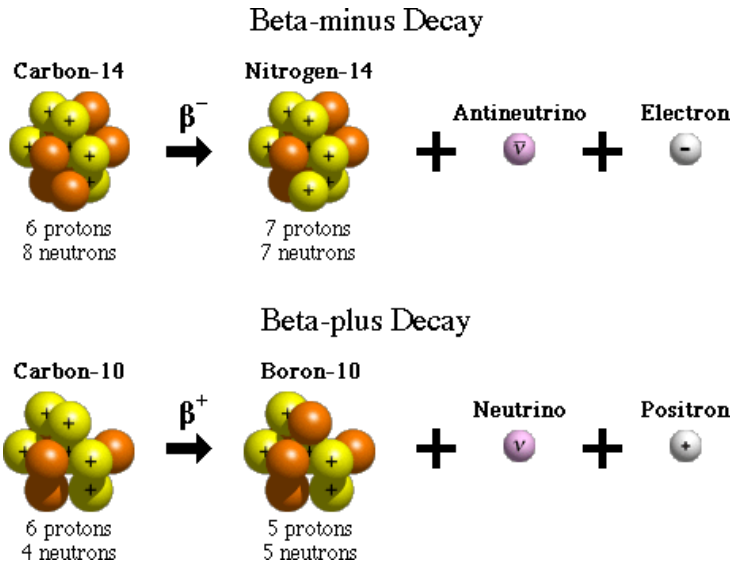
***Next…***

***The process continues with…***

***After this…***

You can also use ***then*** after the subject of your sentence, instead of the beginning:

*The water is then transported*.




**18. In pairs or small groups, choose any topic from the list below and prepare an oral report.**

I. Gravity works the same way on all matter – but what about antimatter?
II. Could we make an anti-world?
III. Could antimatter be used to make the ultimate bomb?

**19. Test yourself.**

1) Can neutrons be transmuted into anti-neutrons?
2) Where is all antimatter?
3) Does antigravity exist? Why do you think so?
4) Do antiparticles attract other antiparticles?
5) Why didn't matter and antimatter annihilate just after the Big Bang?
6) How do scientists make antimatter?
7) Is it possible to keep obtained antiparticles?
8) What is formed after annihilation of matter and antimatter?
9) Can antimatter be used as fuel?
10) Can it have practical medical applications?

LISTENING

**20. Listen to 'What Happened to Antimatter?' and complete the notes. Check and compare your answers.**

1) What does the speaker call 'two currencies with the huge rate'?
2) What does 1 gr. of mass equal?
3) How can matter be transformed in antimatter?
4) What does 50/50 mean here?
5) What do an electron and a positron have in common?
6) How do they differ from protons and anti-protons?
7) What could be done with the amount of energy contained in 1 gr of antimatter?
8) Why don't we use antimatter in energy production?
9) How long did it take antimatter to almost disappear after the Big Bang?
10) Why didn't matter annihilate after the colliding with anti-matter after the Big Bang?

WRITING

**21. Translate the paragraph into Russian.**

Universal Asymmetries

If antimatter were spread across the universe, the annihilation episodes would be occurring all the time. Matter and antimatter would gradually destroy each other in little explosions, mopping each other up. Because we don't see this, there cannot be much antimatter around. In fact normal matter is the only widespread form of particle we see, by a very large margin. So at the outset of the creation of the universe there must have been an imbalance such that more normal matter was created than its antimatter opposite.

**22. Translate the paragraph into English.**

Ёще в 2002 году в Европейском центре ядерных исследований физики впервые получили ощутимое количество антивещества- примерно 50 тысяч атомов антиводорода. Но всё полученное антивещество мгновенно самоуничтожилось, взаимодействуя с нормальным веществом. Ныне физикам удалось собрать полученные атомы в хитрую ловушку- так называемою «магнитную бутылку». Им удалось воспроизвести 38 атомов антиводорода, некоторые из них просуществовали одну десятую долю секунды, что дало ученым достаточную почву для их изучений.

## Part III "NUCLEAR FISSION"

*'…gradually we came to the idea that perhaps one should not think of the nucleus being cleaved in half as with a chisel but rather that perhaps there was something Bohr's idea that the nucleus was like a liquid drop.'*

Otto Frisch, 1967

LEAD-IN

**1. In pairs or small groups, discuss the questions.**

What is nuclear fission?

Why is nuclear power used to produce electricity?

Why is nuclear power very dangerous?

**2. Arrange the sentences of the last paragraph in the right order.**

**3. Read and complete the text using the words below.**

NUCLEAR FISSION

[1] The demonstration of nuclear fission is one of the great highs and lows of science. Its discovery marked a huge 1) _____in our understanding of nuclear physics, and broke the dawn of atomic energy. But the umbrella of war meant this new 2) _____was implemented almost immediately in nuclear weapons, devastating the Japanese cities of Hiroshima and Nagasaki and unleashing a proliferation problem that remains difficult to resolve.

[2] At the start of the 20th century, the atom's 3) _____world began to be revealed. Like a Russian doll, it contains many 4) _____shells of electrons enveloping a hard kernel or nucleus. By the early 1930th, the nucleus itself was 5) _____, showing it to be a mix of positively charged protons and uncharged neutrons, both much heavier than the ephemeral electron, and bonded together by the strong nuclear force. Unlocking the energy glue of the nucleus became a holy grail of scientists.

[3] In nuclear physics and nuclear chemistry, nuclear fission is a nuclear reaction in which the nucleus of an atom 6) _____into smaller parts, often producing free electrons and lighter nuclei, which may eventually produce photons (in the form of gamma rays). Fission of heavy elements is an exothermic reaction which can release large amounts of energy both as electromagnetic radiation and as kinetic energy of the fragments (heating the bulk material where fission takes place). For fission to produce energy, the 7) _____binding energy of the resulting elements has to be higher than that of the starting element. Fission is a form of nuclear transmutation because the resulting fragments are not the same element as the original one.

[4] Nuclear fission produces energy for nuclear power and to drive the explosions of nuclear weapons. Both uses are made possible because certain substances called nuclear fuels undergo fission when struck by 8) _____neutrons and in turn generate neutrons when they break apart. This makes possible a self-sustaining chain reaction that releases energy at a controlled rate in a nuclear reactor or at a very rapid uncontrolled rate in a nuclear weapon.

[5] The amount of free energy contained in nuclear fuel is millions of times the amount of free energy 9) _____in a small mass of chemical fuel such as gasoline, making nuclear fission a very tempting source of energy; however, the products of nuclear fission are radioactive and 10) _____so for significant amounts of time, giving rise to a nuclear waste problem.

[6] 1. __ Plutonium-239 is unstable and its breakdown produces even more neutrons per gram, so mixing in plutonium can trigger the chain reaction readily. 2. __ It is uranium-235 that is the most effective for a fission bomb, so raw uranium is enriched in uranium-235. 3. __ Uranium comes in two types, or isotopes, hosting different numbers of neutrons in their nuclei. 4. __ In nature, very few materials exist that undergo nuclear reaction. 5. __ The most common isotope, uranium-238 is ten times more common than the other, uranium-235. 6. __ When uranium-238 receives a neutron it becomes plutonium-239.

| | | |
|---|---|---|
| splits | remain | contained |
| outer | leap | technology |
| cracked | total | inner |
| free | | |

**4. Read the text again and find the <u>words</u> that mean the same as the following phrases.**

a. producing heat;
b. completely destroying something;
c. was officially decided to be used;
d. a place, person or thing that you get something from;
e. causing a lot of damage or destruction;
f. the increase in the number or amount of something;
g. changing something into something different;
h. an object that is used for fighting or attacking;
i. covering something completely;
j. maintaining or able to maintain oneself or itself by independent effort.

**5. In pairs, discuss and write definitions for the following terms from the text.**

| | | |
|---|---|---|
| Fission | raw | explosion |
| isotope | trigger | fuel |
| radioactive | substance | kinetic |
| | | split |

**6. Choose the phrase which could replace these phrases.**

**A.** the great highs and lows of science

1. achievements in scientific development;
2. successes and failures in scientific development;
3. different directions in science;

**B.** broke the dawn of atomic energy

1. gave the start of it;
2. prevented its development;
3. encouraged production of nuclear weapon;

**C.** unleashing a proliferation problem

1. succeeding in its solution;
2. attempting to solve it;
3. influencing its spread;

**D.** unlocking the energy glue of the nucleus

1. discovering nucleus as a source of energy;
2. discovering the structure of nucleus;
3. discovering the nucleus as a source of electricity;

**E.** a tempting source of energy

1. a profitable way of getting electricity;
2. an attractive way of getting energy;
3. a reliable way of getting energy.

**7. Fill the gaps with the new words in the correct form:**

***devastate, transmutation, self-sustain, trigger, kinetic, raw, proliferation, envelope(v), split, exothermic***

1) Purifying uranium was hard, and neutrons in the experiments were quickly mopped up before they could_____ the fission cascade.

2) Fermi obtained the first_____ chain reaction in 1942 at the University of Chicago.

3) The work of the research team of the Manhattan Project was_____ in mystery.

4) Speed or velocity can be used to calculate the_____ energy.

5) In1917 Ernest Rutherford got _____ of nitrogen into oxygen by firing alpha particles at the gas.

6) Fermi was_____ when his theory of full beta decay was rejected by scientific journal Nature on the basis that it was too speculative.

7) We say the gas is ionized, which means that some of gas molecules have been_____ into positive ions and negative electrons.

8) A _____ of personal computers has greatly influenced the development of technologies.

9) _____ uranium is enriched to be used in the production a sustainable fission.

10) During _____ reaction some heat is released.

**8. Use the words given in brackets to form a word that fits in the gaps.**

1) Dirac thought of the quanta as tiny_____ (oscillate) .
2) Beta radiation involved the_____ (convert) of a down quark in a neutron into an up quark in a proton, while emitting a W-particle.
3) Interference effects are easily_____ (understand) if one thinks of a wave as some sort of displacement in a medium.
4) A sphere has the smallest possible surface area for a given mass, and therefore minimizes neutron_____ (leak) .
5) The amount of critical mass of fissile material is _____ (depend) on several factors: physical properties and nuclear properties, their geometry and purity.
6) In fact, the energy in a few grams of antimatter is enough to transport an_____ (man) spacecraft to Mars in about a month.
7) Fission chain reactions occur because of interactions between neutrons and _____ (fission) isotopes.
8) Questions remained about what the numbers in the _____ (matrix) were and what they meant in real life.
9) The universe is a sea of information; the form we assign to it is_____ (second) .
10) The _____ (come) electron, or other particle, absorbs a photon to produce a second more energetic electron.

**9. Read the text below and think of the word which best fits each space. Use only one word in each space. There is an example at the beginning(0)**
**Example: (0)be**

**FERMI PARADOX**

The detection of life elsewhere in the universe would (0) be the greatest discovery of (1) time. Enrico Fermi wondered (2),given the age and vastness of the universe, and the presence of billions of stars and planets that (3) existed (4) billions of years, we have not yet (5) contacted by (6) other alien civilizations. This was (7) paradox.
Chatting (8) his colleagues over lunch in 1950, physics professor Enrico Fermi supposedly asked 'Where are they?' (9) own Galaxy contains billions of stars and there are billions of galaxies in the universe, so that is trillions of stars. If just a fraction of those anchored planets, that's a lot of planets. If a fraction of those planets sheltered life, then there should be millions of civilizations out (10). So why (11) we seen them? Why haven't they got (12) touch with us?

SPEAKING

**10. Answer the following questions.**

1. What kind of energy is released during a nuclear reaction?
2. Why is it possible to use nuclear fission to produce electricity?
3. Why is the use of nuclear fuel more advantageous than chemical fuel?
4. How does uranium-238 become plutonium-239?

**11. Complete these sentences with information that reflects your personal views.**

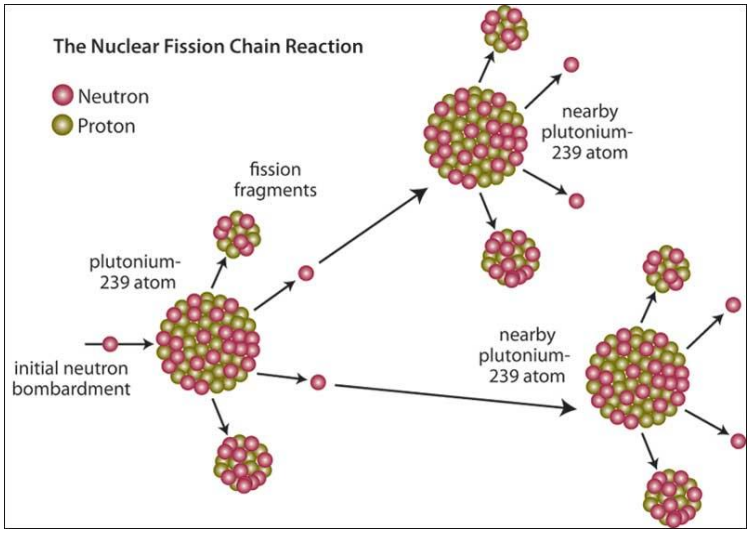
I. To obtain energy by manipulating one or several nuclei of atoms we can do it using two ways…

II. Not all neutrons are able to continue the fission reaction…
III. The amount of critical mass of fissile material is dependent on several factors…
IV. In order to enrich uranium…

**12. Read the statements and mark T (true) or F (false).**

1. In spontaneous nuclear fission the outer absorption is necessary.
2. Plutonium-239 has a low spontaneous fission rate compared with the rate of spontaneous fission of uranium-235.
3. Nuclear fission cannot occur without neutron bombardment.
4. During nuclear fission the sum of the masses of the fragments is smaller than the original mass.
5. The critical mass is the biggest amount of fissile material for a nuclear chain reaction is maintained.
6. The amount of critical mass of fissile material doesn't depend on its purity.
7. The most common use of controlled nuclear fission is in nuclear reactors.
8. The self- sustaining release of neutrons is known as a chain reaction.

**13. Look at the diagram and describe it.**




**14. Complete each sentence by matching it with the appropriate ending.**

1) In nuclear energy we call nuclear fission the action
2) During a nuclear reaction the core becomes different fragments
3) Nuclear fission occurs when a nucleus of a heavy atom
4) A nuclear chain reaction is a process by which neutrons are released in a first nuclear fission
5) Controlled reactions would be produced in nuclear reactions in nuclear plants that
6) If two neutrons are released in each fission caused by a neutron
7) If neutrons released by each nuclear reaction are lost faster than they are formed by the fission rate
8) Light water is the term used

a) the chain reaction will not be self-sustaining and will stop.
b) to produce additional fission in at least one more core.
c) having a mass almost equal to half of the original mass and two or three neutrons.
d) to describe water made using the common isotope protium, which has a single proton in its nucleus.
e) then the number of fissions doubles on each generation.
f) to split the nucleus of an atom.
g) captures a neutron, or can occur spontaneously due to the instability of the isotope.
h) generate electricity where their objective is steadily

**15. In pairs, role-play a conversation in which a scientist explains a layperson what nuclear fission is.**

**16. Test yourself.**

1. Write down the nuclear equation for the alpha decay of:

a) $^{238}_{92}U$ b) $^{230}_{90}Th$ c) $^{241}_{95}Am$

2. Write down the nuclear equation for the beta decay of:

a) $^{234}_{90}Th$, b) $^{90}_{38}Sr$, c) $^{131}_{53}I$.

3. Give a proper definition of half-life.
4. Briefly describe what nuclear radiation does to living cells.
5. Why are alpha particles so good at ionizing atoms?
6. What is the main difference between X-rays and gamma rays?
7. Describe in detail how radioactive sources are used in each of the following:

a) treating cancer, b) tracers in medicine

8. Describe in detail how radioactive sources are used in each of the following:

a) tracers in industry, b) smoke alarms.

9. What type of particle is uranium-235 bombarded in a nuclear reactor to make it split?
10. An old bit of cloth was found to contain 1 part in 80 000 000 carbon-14. If carbon-14 decays with a half-life of 5730 years, find the age of the cloth.
11. Explain how a chain reaction is created in a nuclear reactor.

**17. In pairs or small groups look for information on one of the topics from the list below and prepare an oral report.**

I. Tell how a nuclear reactor works.
II. Tell about the latest achievements in nuclear research.
III. Tell about applications of nuclear power.

LISTENING

**18. Listen and watch "Fission and Fusion" video and be ready to comment it in pairs or small groups.**

WRITING

**19. Translate the paragraph into Russian.**

The Controlled Nuclear Reaction

To maintain a sustained nuclear reaction control for every two or three neutrons released, only one should be allowed to give another uranium nucleus. If this ratio is less than the one then the reaction will die, and if it is larger will grow uncontrollably. To control the amount of free electrons in the reaction space an absorber of neutrons must be present. Most reactors are controlled by control rods made of neutron absorbing material, like boron or cadmium. In addition to the need to capture neutrons, the neutrons often have high kinetic energy. These fast neutrons are reduced through the use of a moderator, such as heavy water and tap water. Some reactors use graphite as a moderator, but this design has some problems. Once the fast neutrons are slowed they are more likely to produce more nuclear fissions or be absorbed by the control bar.

**20. Translate the paragraph into English.**

ПОЧЕМУ ИЗОТОПЫ РАСПАДАЮТСЯ?

В ядре атома находятся протоны, которые сконцентрированы в очень малом пространстве. В ядре атома действуют некие удерживающие силы, которые не дают одноименно заряженным нейтронам

разорвать ядро атома. Но иногда энергия отталкивания частиц превосходит энергию склеивания, и ядро раскалывается на части - происходит радиоактивный распад.

Ученые установили, что все химические элементы, в ядре которых более 84 протонов, являются нестабильными и время от времени подвергаются радиоактивному распаду. Однако, существуют изотопы, в ядре которых меньше 84 протонов, но они тоже являются радиоактивными. Дело в том, что о стабильности изотопа можно судить по соотношению количества протонов и нейтронов атома. Изотоп будет нестабилен, если разность между количеством протонов и нейтронов велика. Изотоп элемента будет устойчивым, если количество нейтронов и протонов в его атоме примерно равно. Поэтому, неустойчивые изотопы, подвергаясь радиоактивному распаду, превращаются в другие элементы. Процесс превращения будет идти до тех пор, пока не образуется устойчивый изотоп.

# Part IV "NUCLEAR FUSION"

*'I ask you to look both ways. For the road to a knowledge of the stars leads through the atom; and important knowledge of the atom has been reached through the stars'*

Sir Arthur Eddington, 1928

LEAD-IN

**1. In pairs or small groups, discuss the questions.**

What is nuclear fusion?

Why are researchers trying to get fusion power on Earth?

Do you believe that they will succeed in this field? Why?

**2. Read and complete the text using the phrases below.**

NUCLEAR FUSION

[1] All elements around us, including those in our bodies, are the product of nuclear fusion. Fusion powers stars like the Sun, within which all the elements heavier than hydrogen are cooked up. We really are made of stardust. If we can harness the stars' power on Earth, fusion [1 __] .

[2] Nuclear fusion is the merging together of light atomic nuclei to form heavier ones. When pressed together hard enough, hydrogen nuclei can merge to produce, helium, giving off energy – a great deal of energy – in the process. Gradually, by building up heavier and heavier nuclei through a series of fusion reactions, all the elements that we se around us can be created from scratch.

[3] Fusing together even the lightest nuclei, such as hydrogen, is tremendously difficult. Enormous temperatures and pressures are needed, so [2 __], like the Sun and other stars. For two nuclei to merge, the forces that hold each one together must be overcome. Nuclei are made up of protons and neutrons locked together by the strong nuclear force. The strong force is dominant at the tiny scale of the nucleus, and much weaker outside the nucleus. Because protons are positively charged, their electrical charges repel one another, so pushing each other apart slightly as well. But the strong force glue is more powerful so the nucleus holds together.

[4] Because the strong nuclear force acts over such a short precise range, its combined strength is greater for small nuclei than for large ones. For a weighty nucleus, such as uranium, with 238 nucleons, the mutual attraction will not be as strong between nucleons on opposite sides of the nucleus. The electric repulsive force, on the other hand, [3 __] and so becomes stronger for large nuclei because it can span the whole nucleus. It is also boosted by the greater numbers of positive charges they contain. The net effect of this balance is that the energy needed to bind the nucleus together, averaged per nucleon, increases with atomic weight up to the elements nickel and iron, which are very stable, then drops off again for larger nuclei. So fission of large nuclei happens relatively easily as they can be disrupted by a minor knock.

[5] For fusion, the energy barrier to overcome is least for hydrogen isotopes that contain just a single proton. Hydrogen comes in three types: 'normal' hydrogen atoms contain one proton surrounded by a single electron; deuterium, or heavy hydrogen, has one proton, one electron and also one neutron; tritium has two neutrons added, so it is even heavier. The simplest fusion reaction therefore is [4 __] a lone neutron. Although it is the simplest, scorching temperatures of 800 million Kelvin are needed to ignite even this reaction.

[6] On Earth, physicists are trying to replicate these extreme conditions in fusion reactors to generate power. However, they are decades [5 __]. Even advanced fusion machines take in more energy than they give out, by orders of magnitude. Fusion power is the holy grail of energy production. (A) Very few atoms are needed to produce huge amounts of energy, there is little waste and certainly nothing as nasty as ultraheavy elements

that come out of fission reactors. (B) Fusion power doesn't produce greenhouse gases either, promising a self-contained, reliable source of energy assuming its fuel, hydrogen and deuterium, can be manufactured. (C)

a. Off from achieving this in practice;
b. Is still felt at larger separations;
c. Could even be the key to unlimited clean energy;
d. The combination of hydrogen and deuterium to form tritium plus;
e. Fusion only happens naturally in extreme places.

**3. Look at the three lettered spaces in the text (A), (B), (C) that indicate where the following sentence can be added to the passage. Where would the sentence best fit?**

*Compared with fission technology, fusion reactions are relatively clean and, should they work, efficient.*

**4. Read the text again and find the words that mean the same as the following phrases.**

a. used to describe actions that affect two or more things equally;
b. to succeed in dealing with or controlling something;
c. a range of levels or numbers used for measuring something;
d. closely connected with something;
e. made something increase, or become better;
f. made it difficult for something to continue in the normal way;
g. to become fewer or less;
h. to control and use the force or strength of something to produce power or achieve something;
i. to start or make something to burn;
j. to combine or make two or more things to form a single thing.

**5. In pairs or small groups discuss the definitions for the following terms from the text.**

| | | |
|---|---|---|
| nucleons | a Kelvin | to press |
| span | replicate | generate |
| atomic | give off | power |
| weight | reactor | |

**6. Fill the gaps with the new words in the correct form:**

***ignite, surround, disrupt, mutual, scale, merge, harness***

a. The material traversed by the charged particle is in a state of chemical combination, and then the moving field of electrical force may _____ the molecules.
b. Fractals are patterns that look essentially the same at any _____
c. Scientists all over the world have been trying to _____ the sun's rays as a source of energy.
d. Ideas were again shared the Atlantic, but it still proved difficult to_____ a chain reaction in the laboratory.
e. In physics and nuclear chemistry, nuclear fusion is the process by which multiple atomic particles_____ to form a heavier nucleus.
f. They soon discovered a _____ interest in superconductivity.
g. Fermi found that, if the neutron source were _____ by water, or any substance containing a large proportion of hydrogen, it frequently was more efficient in producing radioactivity.

**7. What does the author mean by saying the following? Choose the best explanation.**

**A.** all elements heavier than hydrogen are cooked up

1. All the elements except hydrogen burn up at extreme temperatures;
2. All the elements whose atomic weight is bigger than hydrogen's merge and release a lot of energy at extreme temperatures;
3. All heavy turn into light hydrogen at extreme temperatures;

**B.** We really are made of stardust

1. Our Earth is polluted by stardust;
2. Human bodies absorb a lot of star dust;
3. Everything on our planet is made of elements having been produced during fusion reactions on the Sun;

**C.** For two nuclei to merge, the forces that hold each one together must be overcome.

1. To make two nuclei join is very difficult because all nuclei have a positive charge, and they strongly resist being put too close together;
2. To make two nuclei join is difficult because gravitational force prevents it;
3. To make two nuclei join together is difficult because the strong force is more powerful than other forces;

**D.** They are decades off from achieving this in practice

1. In twenty years it will be possible to get energy from the first fusion reactors;
2. Nowadays scientists can't predict when they will be able to get energy from the fusion reactors;
3. No scientists in the world are seriously working on getting artificial thermonuclear energy on our planet;

**E.** Fusion power is the holy grail of energy production

1. It will become the source of the unlimited clean energy;
2. It will be very profitable for energy industry;
3. It will completely change some laws in physics.

**8. For each set find one word mentioned in the text that will fit all sentences.**

(A)

1) They obtained the results like _____

2) Men work in a _____ to extract coal, gold and other minerals.

3) During a war soldiers use_____ to explode tanks.

(B)

1) A _____ provides various financial services, for example keeping or lending money.

2) It's located on the left _____ of the Thames.

3) The sun disappeared behind a _____ of clouds.

(C)

1) Only _____ vehicles are allowed over the old bridge.

2) A _____ was still burning in the room.

3) Don't turn on the _____. It's not dark yet.

**9. Fill in the gaps with words derived from the words in brackets.**

1) _____ (gas) condition is important, even at low pressures.
2) If we consider a distribution of hydrogen in equilibrium at zero temperature, the presence of the matter produces a_____ (curve) of space.
3) Brief descriptions of the most important instruments, and of the methods of observing the phenomenon along with the _____ (criterion) used, are given in this chapter.
4) A high degree of accuracy is sometimes sacrificed for _____ (simple) in order to meet these demands.
5) This fact is not representative of the connection between the movement of the plasma _____ (regular) in the ionosphere and the state of the geomagnetic field.
6) During the experiment electric and magnetic fields cause _____ (deflect) of moving charged nuclei which depend on the mass of the nuclei.
7) In atomic reactions electrons are conserved and act as _____ (destruct) particles.
8) It can support entirely new kind of _____ (compute) with_____ (quality) new algorithms based on quantum principles.
9) Both _____ (radius) of curvature may be changed, but the difference in curvature is kept constant by bending the lens.

10) These systems produce a _____ (sphere) focal surface, and when they are used for cameras the film must be curved to fit this focal surface.

**10. Choose the correct answer A, B, or C from the list below.**

Natural Occurrence

In nature, fusion occurs in stars. On Earth, nuclear fusion was first achieved in the explosion of the 1) _____bomb. In a non-destructive manner, fusion has also reached in different experimental devices 2) _____at studying the possibility of producing energy in a controlled fashion.3) _____, fission is a nuclear process which does not normally occur in nature. The reason for this is that it requires a large mass and an incident 4) _____to initiate the process. But there have been 5) _____where nuclear fission has occurred in natural reactors.

If accidentally, a fission reactor goes out of control as a result of not controlling the emission of neutrons, a nuclear meltdown can happen which can the 6) _____highly radioactive particles in the atmosphere. In contrast, in case of nuclear fusion if the reactor goes out of control, the reaction would 7) _____automatically as it will cool down. In addition, in case of nuclear fusion reaction, the amount of radioactive materials produced as 8) _____is very small and the 9) _____damage which could happen is the 10) _____of anything in the immediate vicinity of the reaction.

| | | | |
|---|---|---|---|
| 1) | A nuclear | B hydrogen | C neutron |
| 2) | A produced | B tested | C aimed |
| 3) | A on the other hand | B moreover | C although |
| 4) | A proton | B electron | C neutron |
| 5) | A incidents | B accidents | C examples |
| 6) | A release | B absorb | C collide |
| 7) | A continue | B stop | C change |
| 8) | A waste | B energy | C electricity |
| 9) | A minimum | B maximum | C average |
| 10) | A vaporization | B freezing | C heating |

**11.Read the text below and think of the word which best fits each space. Use only one word in each space. There is an example at the beginning (0)**

**Example: (0)nobody**

STRING THEORY

String theory is an entirely mathematical idea. (0) has ever seen a string, and no one has any idea (1) to know if one were there (2) sure. So there are (3) experiments that anyone (4) yet devised that could test (5) the theory is true or not. It is said that there are as (6) string theories as there are string theorists. This puts the theory in an awkward position (7) scientists.

The philosopher Karl Popper thought that science proceeds mainly by falsification. You can come (8) with an idea, test it with an experiment and if it is false (8) that rules something (9), so you learn something new and science progresses. If the observation fits the model then you have not learned (10) new. Because string theory is (11) fully developed (12) does not yet have any definite falsifiable hypotheses. Because there are (13) many variations of the theory, (14) scientists argue it is not real science.

**12. Complete each sentence by matching it with the appropriate ending.**

1) At large distances two naked nuclei repel one another because

2) If two nuclei can be brought close enough together

3) Fusion power does not produce

4) Very few atoms are needed

5) At the high temperatures involved, controlling the scorching gases

6) Fusion power is not perfect and will

a) produce some radioactive by-products as neutrons are released in the main reactions.

b) is the main difficulty, so although fusion has been achieved these machines only work for a few seconds at a time;

c) greenhouse gases;

d)of the repulsive electrostatic force between their positively charged protons;

e) to produce huge amounts of energy;

f) the electrostatic repulsion can be overcome by attractive nuclear force which is stronger at close distance.

SPEAKING

**13. Choose a sentence which expresses the main idea of the text.**

- Fusion is a fundamental power source across the universe;
- It's not easy to harness the enormous power of the stars;
- Fusion is the most efficient solution of the energy crisis.

**14. Answer the questions to the text.**

1. Why does fusion happen naturally only in extreme places?
2. Why is the strong nuclear force greater for small nuclei than for large ones?
3. What isotopes can be used for the simplest fusion reaction? Why?
4. Why is it difficult to generate power from fusion on Earth?

**15. Complete these sentences with information that reflects your personal views.**

I. The deuterium-tritium fusion reaction is the most promising for producing sustainable fusion power…
II. Research into controlled fusion is accompanied by extreme scientific and technological difficulties…
III. In order to be useful as a source of energy, a fusion reaction must satisfy several criteria…

**16. Read the sentences and mark T (true) or F (false).**

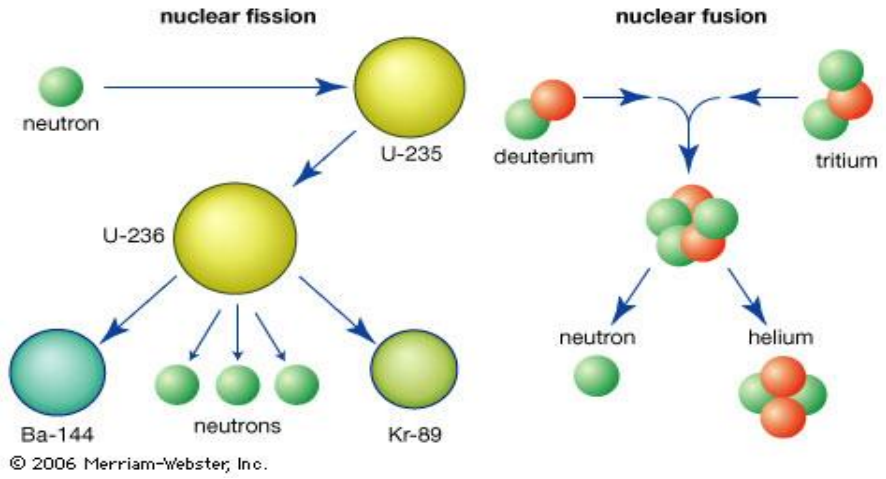
1. In physics, nuclear fusion is the process by which multiple atomic particle are joint together to form a heavier nucleus.
2. It takes relatively little energy to force nuclei to fuse.
3. Whereas the fusion of heavy elements in stars releases energy, production of the lightest elements absorbs energy.
4. The energy released in most nuclear reactions is much larger than in chemical reactions.
5. The fusion of two nuclei lighter than iron generally absorbs energy while the fusion of nuclei heavier than iron releases energy.
6. Nuclear fusion occurs naturally in stars.
7. Reactions which are not self-sustaining can release considerable energy, as well as numbers of neutrons.
8. When the fusion reaction is a sustained uncontrolled chain, it can result in a thermonuclear explosion.

**17. Test yourself.**

1. What happens during nuclear fusion?

2. What reaction is considered the most promising for producing sustainable fusion power?
3. What elements have the largest binding energies per nucleon of all nuclei?
4. Does fusion only release energy, or it can absorb energy?
5. Where does fusion occur naturally?
6. Has artificial fusion in human enterprises achieved?
7. What process is called nucleosynthesis?
8. What scientific and technological difficulties the controlled fusion is accompanied by?
9. How can scientists overcome electromagnetic repulsion to achieve fusion?
10. Do fusion or fission reactions have a greater energy density per unit of mass?

**18. Look at the chart and describe it.**




**19. In pairs role-pay a conversation in which a scientist explains a layperson the necessity of further research into fusion.**

LISTENING

**19. Listen to "Nuclear Fusion" and complete the notes. Check and compare your answers.**

1. Nuclear fusion is…
2. It releases more energy than…
3. What happens during the reaction of nuclear fusion?
4. Why is it so important to harness the fusion power?

WRITING

**23. Translate the paragraph into Russian.**

Stardust

Stars are nature's fusion reactors. Within stars, heavier elements are gradually built up in steps by fusion. Larger and larger nuclei are constructed through a succession of burning first hydrogen, then helium, then other elements lighter than iron and, eventually, elements heavier than iron. Stars like the Sun shine because they are mostly fusing hydrogen into helium and this proceeds slowly enough that heavy elements are made in only small quantities. In bigger stars this reaction is sped up by the involvement of the elements carbon, nitrogen and oxygen in further reactions. So more heavy elements are made more quickly. Once helium is present, carbon can be made from it. As soon as some carbon is made it can combine with helium to make oxygen, neon and magnesium. These slow transformations take most life of the star.

**24. Translate the paragraph into English.**

Радиационная безопасность

Термоядерный реактор намного безопаснее ядерного реактора в радиационном отношении. Прежде всего, количество находящихся в нем радиоактивных веществ сравнительно невелико. Энергия, которая может выделиться в результате  какой-либо аварии, тоже мала и не может привести к разрушению реактора. При этом в конструкции реактора есть несколько естественных барьеров, препятствующих распространению радиоактивных веществ. Например, вакуумная камера и оболочка криостата должны быть герметичными, иначе реактор просто не будет работать. Для того, чтобы предотвратить распространение радиоактивных веществ, если они выйдут за пределы вакуумной камеры и криостата, необходима специальная система вентиляции, которая должна поддерживать в здании реактора пониженное давление. Поэтому из здания не будет утечек воздуха, кроме как через фильтры вентиляции.

**25. Write an article in which you can compare the properties and their strong and weak sides and express your opinion on the future possibilities to use these kinds of energy to get electricity.**

| | **Nuclear Fission** | **Nuclear Fusion** |
|---|---|---|
| Definition | Fission is the splitting of a large atom into two or more smaller ones. | Fusion is the fusing of two or more lighter atoms into a larger one. |
| Natural occurrence of the process | Fission reaction does not normally occur in nature. | Fusion occurs in stars, such as the sun. |
| Byproducts of the reaction | Fission produces many highly radioactive particles. | Few radioactive particles are produced by fusion reaction, but if a fission "trigger" is used, radioactive particles will result from that. |
| Conditions | Critical mass of the substance and high-speed neutrons are required. | High density, high temperature environment is required. |
| Energy Requirement | Takes little energy to split two atoms in a fission reaction. | Extremely high energy is required to bring two or more protons close enough that nuclear forces overcome their electrostatic repulsion. |
| Energy Released | The energy released by fission is a million times greater than that released in chemical reactions, but lower than the energy released by nuclear fusion. | The energy released by fusion is three to four times greater than the energy released by fission. |
| Nuclear weapon | One class of nuclear weapon is a fission bomb, also known as an atomic bomb or atom bomb. | One class of nuclear weapon is the hydrogen bomb, which uses a fission reaction to "trigger" a fusion reaction. |
| Energy production | Fission is used in nuclear power plants. | Fusion is an experimental technology for producing power. |
| Fuel | Uranium is the primary fuel used in power plants. | Hydrogen isotopes (Deuterium and Tritium) are the primary fuel used in experimental fusion power plants. |

**How to Write a Scientific Article:**

**'Cookbook' for the Introduction, Methods and materials, Results, and Discussion Sections**

Consult this 'cookbook' to get instructions for creating the four most difficult parts of the article so they will do what a scientific reader expects them to do. As you write, turn to the section you are working on and make sure it follows these instructions in the order they are given.

**INTRODUCTION**: The introduction answers the questions: what, why?, and how? ("who?"and where? and when? are identified on your title page by your name, course, and date.)

Teach the reader about your subject:

Define the subject, describing those characteristics of the structure, chemical, etc. you will study and explaining those characteristics' importance. As you do, mention pertinent literature that discusses previous research on your subject.

Describe the controversy or question which requires you to perform this experiment, referring to the literature mentioned in (…)

State how your experiment addresses this question or controversy. (your purpose)

Finish with the major finding of your report, in one sentence if possible.

**MATERIALS AND METHODS**: This section describes the essential stages of the procedure necessary to reproduce this experiment.

Tell the reader how to repeat your experiment:

Explain the source of chemicals or something else.

Explain your 'experimental design', including the number and types of substances, ,quantities and concentrations of chemicals, make and model of unusual equipment, essential conditions (heat/cold, time agitation or other stimuli)

Explain procedures used to measure effects you studied

**RESULTS**: the Results section reports, without conclusions or discussion, specific effects the MATERIALS AND METHODS said you were looking for.

Tell the reader what you found, dividing results of complicated experiments into types and reporting each type of result in a separate paragraph:

Open each results paragraph with one general sentence stating the part of procedure used to see the result described in that paragraph (should correlate with 3) in Materials and Methods)

List your results in tables or in clear figures. You MUST refer to every figure or table in the text.

**DISCUSSION**

In you discussion, you must ANALYZE and EXPLAIN your results.

Link your results to your original hypotheses.

Explain your experimental observations in specific terms.

Discuss possible sources of error and how they might have affected your results.

Compare your results to those of similar experiments published elsewhere.

Draw overall conclusions.

This is your chance to show us your capacity for creative, scientific thought. Refer to literature and other published material on the subject, but offer your own insights and ideas about your observations.

UNIT ONE. VOCABULARY LIST

| | |
|---|---|
| absorption n | infinitesimal, adj |
| bond ,v | leftover (n) |
| boost, v | map (v) |

by-product, n

complementary, adj

conjugation, n

devastate, v

disrupt, v

emerge, v

emission, n

Enrich, v

envelope, v

equation, n

equivalence, n

exothermic, adj

fissile, v

harness (v)

ignite, v

implement, v

infer (v)

mediate (v)

minuscule (adj)

multiplication (n)

parity (n)

perpendicular (adj)

proliferation (n)

purity (n)

replicate (v)

repulsive (adj)

seek (v)

self-sustaining (adj)

spontaneous (adj)

transmutation (n)

trigger (v)

undergo (v)

unleash (v)

vicinity (n)

APPENDIX: Mathematical symbols in English

| **Symbol** | **Name** | **Read as** | **Symbol** | **Name** | **Read as** |
|---|---|---|---|---|---|
| = | equality | equals, is equal to | ∏ | multiplication | product over … from … to …of |
| ≡ | definition | is defined as | ! | factorial | factorial |
| ≈ | approximately equal | is approximately equal to | ⇒ | material implication | implies |
| ≠ | inequation | does not equal, is not equal to | ⇔ | material equivalence | if and only if |
| < | strict inequality | is less than | \|…\| | absolute value | absolute value of |
| > | | is greater than | \|\| | parallel | is parallel to |
| ≪ | | is much less than | ⊥ | perpendicular | is perpendicular to |
| ≫ | | is much greater than | ≅ | congruence | is congruent to |
| ≤ | inequality | is less than or equal to | ϕ | golden ratio | golden ratio |
| ≥ | | is greater than or equal to | ∞ | infinity | infinity |
| ∝ | proportionality | is proportional to | ∈ | set membership | is an element of |
| + | addition | Plus | ∉ | | is not an element of |
| - | subtraction | Minus | {,} | Set brackets | the set of |
| × | multiplication | Times | ℕ | Natural numbers | N |
| ∑ | summation | sum over … from … to … of, sigma | ℤ | Integers | Z |
| ÷ | division | divided by | ℚ | Rational numbers | Q |
| / | slash | over smth; divided by | ℝ | Real numbers | R |
| ± | plus-minus | plus or minus | ℂ | Complex numbers | C |
| ∓ | minus-plus | minus or plus | x̄ | Mean | bar, overbar |
| √ | square root | square root | x̄ | complex conjugate | the complex conjugate of x |

# UNIT TWO: SPACE AND TIME

# Part I "The Solar System"

*"The sun, with all those planets revolving around it and dependent on it, can still ripen a bunch of grapes as if it had nothing else in the universe to do."*

Galileo Galilei

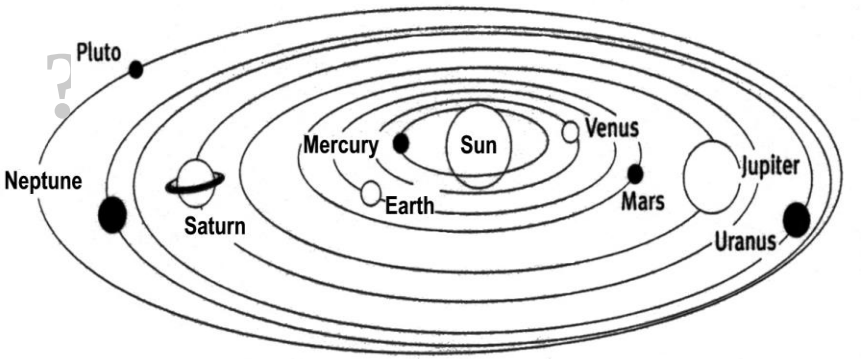
Before we set off on a journey through space and time, take a few minutes and do the quiz!

**Cosmology quiz**

1. How long does it take light from the sun to reach the earth?
   a) 1 minute and 8 seconds;
   b) 8 minutes and 18 seconds;
   c) 18 minutes and 8 seconds;
2. How old is the sun?
   a) 4.6 billion years;
   b) 15 billion years;
   c) 1 million years.
3. Which planet is the hottest?
   a) Mars;
   b) Mercury;
   c) Venus.
4. Which of the planets, other than Earth, has an atmosphere and seasons?
   a) Uranus;
   b) Venus;
   c) Mars.

LEAD-IN

**1. Read the introduction.**




The **Solar System** includes the Sun, eight planets, the Asteroid belt, comets, and meteors. All bodies of the Solar System are separated by enormous distances and are **visible** because they **reflect** the **sunlight**. The study of the Solar System has been developing actively since the invention of the telescope in the 17th century. In the telescope planets seem to be larger than the stars as they are closer. Almost all planets **rotate** and **revolve** in the same direction, which is **counterclockwise**, and lie in the same **plane**.

**2. Try to explain each word below in pairs (use cards).**

| | | |
|---|---|---|
| the Solar System | the interstellar space | the Heliosphere |
| the Sun | a planet | the Milky Way galaxy |
| the inner Solar System | an asteroid | a collision |
| the outer Solar System | a comet | a spacecraft |
| the Kuiper belt | a meteorite/meteor | |

**3. Try to match each term with its definition.**

| | | | |
|---|---|---|---|
| 1. | solar system | a. | a very large hot ball of gas that appears as a small bright light in the sky at night |
| 2. | the Sun | b. | a mass of rock that moves around in space |
| 3. | a star | c. | the planet on which we live |
| 4. | a planet | d. | a star and the planets that go round it, especially the Sun and the group of planets |

| | | | |
|---|---|---|---|
| | | | that includes the Earth |
| 5. | the Earth | e. | a very large round object that moves around the Sun or another star |
| 6. | an asteroid | f. | the star in the sky that provides light and warmth to the Earth |
| 7. | the asteroid belt | g. | a large piece of rock from space that passes into the Earth's atmosphere and appears as a bright light in the sky |
| 8. | a comet | h. | a bright object in space that has a tail of gas and dust |
| 9. | a meteor | i. | an extremely large group of stars and planets |
| 10. | a meteorite | j. | a region of space between the planets Jupiter and Mars where most asteroids are found |
| 11. | a galaxy | k. | space between the stars |
| 12. | a spacecraft | l. | an extended shell of icy objects that exist in the outermost reaches of the solar system; it is roughly spherical, and is the origin of most of the long-period comets |
| 13. | the interstellar space | m. | a piece of rock that has fallen from space and landed on the ground |
| 14. | the Kuiper belt | n. | a very small star that does not shine brightly |
| 15. | The Oort Cloud | o. | a region of the Solar System beyond the planets, extending from the orbit of Neptune (at 30 AU) (Astronomical units) to approximately 50 AU from the Sun; it contains small solar system bodies made mostly of ices |
| 16. | a dwarf (planet) | p. | a vehicle that can travel in space |
| 17. | the Milky Way | q. | the group of planets and stars that the Earth belongs to and that you can see at night as a band of pale light across the sky |
| 18. | a collision | r. | an accident in which a thing that is moving crashes into something |

LISTENING AND READING

**4. Before the listening, make sure you understand the following verbs:**

| | | |
|---|---|---|
| to grow out of | to earn the name | to demote |
| to collide | to maintain | to stretch |
| to float | to establish | to clear away |
| to reach | to fail | to traverse |

**5. Listen to or watch a video about the Solar System done by Space School project. What information was new for you?**

**6. Put the abstracts from the lisening in the correct order. Listen again and check yourself.**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| **j** | | | | | | | | | |

THE SOLAR SYSTEM

a) After almost 80 years Pluto lost its status as the ninth planet. The international astronomical union couldn't ignore findings that similar, even larger bodies than Pluto, traverse the outer Solar System.

b) Finally, after millions of **collisions**, the body must have cleared away other objects from its own orbital **neighborhood**. This last point is where Pluto fails. So it's been demoted to a **dwarf** planet and joined two other dwarves: Eris and Ceres. Astronomers believe there may be as many as 42 dwarf planets in our solar system.

c) Forced to define the word for the first time, astronomers established 3 distinct criteria to earn the name "planet". First, the object must **orbit** the sun. Second, it must have sufficient gravity to maintain a planet's spherical shape.

d) Pluto and beyond is not simply the beginning of endless open space but the **inner** edge of a gigantic region filled with asteroids, comets, and meteorites. Billions of miles beyond our sun stretches the Kuiper belt – an area larger than our entire planetary system. It's home to most of our Solar System's comets, icy flying rocks.

e) Still, despite overwhelming odds, we humans have set out on a journey of exploration. We're sending one spacecraft after another into the **farthest** regions of the solar system all in the quest to understand our place in the Universe and the mystery of the great beyond.

f) The four planets of the outer Solar system make up 99% of the known mass orbiting the sun. It was in that distant region of the **outer** Solar system that in the year 2006 astronomy was shaken to its very core.

g) The sun's gravity then locked them in the orbit. The Solar system is divided into two distinct regions: Mercury, Venus, Earth, and Mars make up the inner solar system, while Jupiter, Saturn, Uranus, and Neptune make up the outer Solar system.

h) There're more than 3, 350 known comets in our Solar system. Further out, still, is the **scattered** disk, a belt of strangely orbiting objects, often small and icy minor planets. Finally, we reach the Heliosphere, an immense magnetic bubble, which forms the very outer edge of the Solar system.

i) This area is thought to be the boundary between **solar** and **interstellar** winds – the boundary between our own neighborhood and the great expanse of the interstellar space. For us the Solar system seems enormous. Its distances are almost beyond our comprehension. But incredibly it's just a tiny corner of the giant Milky Way galaxy.

j) Today's topic, at 4.6 bln years old, is the solar system. Its planets, including our own earth, formed out of what was left over after the birth of the sun. Amazingly, these 8 **massive** celestial bodies grew out of tiny specks of dust orbiting the new star. Time and again*, the young planets collided while floating debris** eventually reaching their current size.

_____
* time and again = frequently, often, many times
** debris /'deibri/ or /'debri/ – fragments or remnants

**7. What was the purpose of these statements in the text? Choose one which explains each of them better.**

**A.** "The international astronomical union couldn't ignore findings that similar bodies traverse the outer Solar system."

1. There are a lot of dwarf planets like Pluto.
2. Pluto was never regarded as a planet.
3. All dwarf planets are larger than Pluto.
4. All dwarf planets are outside our Solar system.

**B.** "Forced to define the word for the first time, astronomers established 3 distinct criteria to earn the name planet."

1. Astronomers always wanted to find distinct criteria.
2. The status of Pluto made astronomers define distinct criteria.
3. Other bodies like Pluto forced the astronomers to define 3 criteria.
4. There used to be only 2 distinct criteria.

**C.** "Its planets including our own earth formed out of what was left over after the birth of the sun."

1. All planets initially were quite big in size.
2. All planets were born from the Sun.
3. The birth of the Sun gave material for future planets.
4. All planets were formed out of pieces of rocks.

**8. Choose three statements which better summarize the content of the article.**

- The Solar system is divided into the inner and outer.

- Pluto is not a planet.
- There are more than 3350 known comets in the Solar system.
- There are some reasons why Pluto has been demoted to a dwarf planet.
- The Solar system is very old.
- The distances in space are huge.

**9. Answer the questions.**

1. Draw in your copy book (or on the blackboard) and explain the general structure of the Solar System and beyond it.
2. What are the criteria for an object to be called a planet?
3. Why Pluto is not a planet anymore?

VOCABULARY

**10. Match an adjective with its Russian translation.**

| | |
|---|---|
| gigantic | огромный |
| Immense | гигантский |
| Enormous | необъятный, огромный, бескрайний |
| Giant | массивный |
| Tiny | ошеломительный, потрясающий |
| Massive | гигантский |
| Overwhelming | крошечный |

**11. In cosmology there are a few adjectives of Latin and Greek origin denoting "having to do with". Complete the list of adjectives:**

Mars *Martian*

Sun _____

Moon _____

Sky _____

Earth _____

Star _____

**12. For each set find one word mentioned in the text The Solar System that will fit all sentences (it must be one word but may be different forms and parts of speech)**

**A.**

a) It is set in the world of the traditional fairy tale, with a cast of elves, _____, trolls and goblins as well as hobbits and humans.
b) The stellar wind from the red _____ star removes the dust in the debris disk by causing the dust to slowly spiral into the star.
c) Jack was abnormally small because of a medical condition and everybody called him a _____.

**B.**

a) This is because Venus and the _____ orbit the Sun at a slight angle to each other.
b) They felt the _____ shaking beneath their feet.
c) Older electrical systems in council flats don't have _____wires.

**C.**

a) How many _____does the hotel have?
b) All the big _____were at the party.
c) Have you read your _____today? (British Informal *a horoscope*)
d) Later, astronomers further scrutinized this _____with the Hubble Space Telescope.

**13. Find a synonym to the first word.**

to float: to swim slowly / to run fast / to move freely / to fly high

to maintain: to keep at the same level or condition / to become important / to be strong and stiff

to demote: to demotivate / to lose status / to deny / to make less popular

to establish: to build / to estimate / to create / to discuss

**14. Choose the most suitable words (not all!) to fill in the gaps.**

PART **A**

*plane circular giant terrestrial consists orbits outer metal gas massive ice planets*

The Solar System 1_____ of the Sun and its planetary system of eight 2_____, their moons, and other non-stellar objects. It formed 4.6 billion years ago from the collapse of a 3_____ molecular cloud. The vast majority of the system's mass is in the Sun, with most of the remaining mass contained in Jupiter. All planets have almost 4_____ 5_____ that lie within a nearly flat disc called the ecliptic 6_____.

PART **B**

*plane circular giant terrestrial consists orbits outer metal gas massive ice planets*

The four smaller inner planets, Mercury, Venus, Earth and Mars, also called the 1_____ planets, are primarily composed of rock and 2_____ . The four 3_____ planets, called the 4_____ giants, are substantially more 5_____ than the terrestrials. The two largest, Jupiter and Saturn, are composed mainly of hydrogen and helium; the two outermost planets, Uranus and Neptune, are composed largely of ices, such as water, ammonia and methane, and are often referred to separately as "6_____ giants".

**15. Use all the words to fill in the gaps. Do not change the form of the words.**

PART **A**: *further interstellar approximately bubble flow scattered*

The solar wind, a 1_____ of plasma from the Sun, creates a 2_____ in the 3_____ medium known as the heliosphere, which extends out to the edge of the 4_____ disc. The Oort cloud, which is believed to be the source for long-period comets, may also exist at a distance 5_____ a thousand times 6_____ than the Heliosphere.

PART **B**: *rotating plane counterclockwise close orbit dominates*

The principal component of the Solar System is the Sun, a G2 main-sequence star that contains 99.86 percent of the system's known mass and 1_____ it gravitationally. The Sun's four largest orbiting bodies, the gas giants, account for 99 percent of the remaining mass, with Jupiter and Saturn together comprising more than 90 percent.

Most large objects in orbit around the Sun lie near the 2_____ of Earth's orbit, known as the ecliptic. The planets are very 3_____ to the ecliptic while comets and Kuiper belt objects are frequently at significantly greater angles to it. All the planets and most other objects 4_____ the Sun in the same direction that the Sun is 5_____ (6_____).

**16. Use the words given in bold to form a word that fits in the space in the same line.**

The Moon (or Luna) is the Earth's only _____ satellite and was _____ 4.6 billion years ago around some 30–50 million years after the formation of the _____ system. The Moon is in synchronous _____ with Earth, meaning the same side is always _____ the Earth. The first unmanned mission to the Moon was in 1959 by the Soviet _____ Program but the first _____ landing was Apollo 11 in 1969.

1. **nature**
2. **form**
3. **sun**
4. **rotate**
5. **face**
6. **moon**
7. **man**

WRITING

**17. Find the following phrases back in the text above. Translate them into Russian as if you were a professional translator.**

*astronomy was shaken to its very core* _____

*beyond our comprehension* _____

*set out on a journey of exploration* _____

*in the quest to understand our place* _____

*despite overwhelming odds* _____

**18. Translate the text into Russian.**

**The Sun**

The Sun is the star at the centre of our solar system. It lies about 150 million km (or 8.3 light minutes) away from Earth and has a diameter of 1,391,000 km (864,300 miles). The Sun's composition is almost three-quarters hydrogen, roughly one-quarter helium (by mass), while heavier

elements make up less than 2 per cent.

The Sun generates energy by nuclear fusion of hydrogen in its core. Heat moves out to the ‘photosphere' where the sunlight we see originates. Beyond that a thin 'corona' expands outwards to form the solar wind, a stream of particles that constantly blows out into space. Sunspots are temporary, relatively cool patches on the Sun where magnetic fields have suppressed heat transfer to the surface.

The Sun formed from a collapsing gas cloud about 4.57 billion years ago. Around 5 billion years from now, it will expand into a red giant star, its outer layers engulfing the planets Mercury, and Venus, and possibly the Earth. Eventually, it will shrink into a hot and dense white dwarf.

**Task 19. Translate the text into English.**

**Heliosphere**

Гелиосфера — область околосолнечного пространства, в которой плазма солнечного ветра движется относительно Солнца со сверхзвуковой скоростью. Извне гелиосфера ограничена бесстолкновительной ударной волной, возникающей в солнечном ветре из-за его взаимодействия смежзвёздной плазмой и межзвёздным магнитным полем.

Первые 10 миллиардов километров скорость солнечного ветра составляет около миллиона километров в час. По мере того, как он сталкивается с межзвёздной средой, происходит его торможение и смешение с ней. Граница, на которой происходит замедление солнечного ветра, носит название границы ударной волны; граница, вдоль которой уравновешивается давление солнечного ветра и межзвёздной среды, носит название гелиопаузы; граница, на которой происходит столкновение межзвёздной среды с набегающим солнечным ветром — головная ударная волна.

PRESENTATION: PLANETS

**20.** Choose one object of the Solar System and give a short presentation about it touching upon the following characteristics (see the table below). Your time limit is 4 minutes + 1 min for questions.

**21.** Copy the table into your copy book. Listen to every presentation and fill in the blocks where possible. Afterwards you will be given a short test on this material.

| **Mercury** | **Uranus** | **Earth** | **Pluto *** |
|---|---|---|---|

**Neptune** **Saturn** **Venus** **Moon ***

**Mars** **Jupiter** **Sun**

| | Order from the Sun | discovered, by who | Size | Weight | Composition, color | Atmosphere | Satellites | Orbit, rotation, revolution | Interesting fact |
|---|---|---|---|---|---|---|---|---|---|
| Mercury | | | | | | | | | |
| Neptune | | | | | | | | | |
| Mars | | | | | | | | | |
| Uranus | | | | | | | | | |
| Saturn | | | | | | | | | |
| Jupiter | | | | | | | | | |
| Earth | | | | | | | | | |
| Venus | | | | | | | | | |
| Pluto | | | | | | | | | |
| Moon | | | | | | | | | |
| Sun | | | | | | | | | |

MINI-GRAMMAR: ARTICLES

**22. Explain the use of articles (the, a/an, zero) in the following extract.**

(1) The heliosphere is (2) the immense magnetic bubble containing our (3) solar system, (4) solar wind, and (5) the entire solar magnetic field. It extends well beyond (6) the orbit of Pluto. While (7) the density of (8) particles in the heliosphere is very low (it's (9) a much better vacuum than is created in (10) a laboratory), it

is full of particles of (11) interest to (12) heliospheric scientists. Check out (13) the image below for (14) a diagram of the heliosphere.

**23. Use articles (the, a/an, zero) where necessary.**

When (1) ___ solar winds hit (2) ___ local interstellar medium, (3) ___ kind of (4) ___ bubble forms that prevents (5) ___ certain material from getting in. Thus, (6) ___ heliosphere acts as (7) ___ kind of (8) ___ shield that protects (9) ___ our solar system from (10) ___ cosmic rays, which are (11) ___ dangerous interstellar particles. (12) ___ interaction between interstellar gas and (13) ___ solar winds depends on (14) ___ pressure of (15) ___ solar winds and properties of interstellar space, such as (16) ___ pressure, (17) ___ density, and qualities of (18) ___ magnetic field. (19) ___ astronomers believe that (20) ___ other solar systems have (21) ___ their own heliospheres caused by (22) ___ different stars.

**24. Test yourself.**

1. What is the solar system? How did the solar system form?
2. How old is the solar system? How big is the solar system?
3. How many planets are there in our solar system? Can you see any planets with the "naked eye?"
4. Which planets are called the "rocky" or "terrestrial" planets? Which planets are called the "gaseous" planets?
5. What is the hottest planet in our solar system? What planet is famous for its big red spot on it?
6. Which planets have rings? How thick are these rings?
7. Ganymede is a moon of which planet?
8. What is the name of Saturn’s largest moon?
9. Olympus Mons is a large volcanic mountain on which planet?
10. Is the planet Neptune bigger than Earth?
11. What is a comet? How did comets form? Why do comets have tails? Where do comets come from? What path do comets follow through the solar system?
12. What is the difference between a meteor, a meteoroid, a meteorite, an asteroid and a comet? What is the asteroid belt?

# Part II “The Universe”

*"The universe is wider than our views of it."*

Henry David Thoreau

LEAD-IN

**Cosmology** (from the Greek *kosmos* "world" and *-logia* "study of") is the branch of astronomy that deals with the evolution and structure of the Universe. Physical cosmology is the scientific study of the origin, evolution, large-scale structures and dynamics, and ultimate fate of the universe, as well as the scientific laws that govern these realities.

READING

**1. Read the text. In Para 7 all sentences are mixed. Put them in the right order.**

## THE BIG BANG

[1] **Cosmology** is the search for origins. The origin of the universe remains one of the greatest questions in science.

[2] According to **the Big Bang** theory, our **Universe** came into being as an infinitesimally small, infinitely hot, infinitely dense, something – a "singularity" around 13.7 billion years ago. Singularities are zones of infinite density that are thought to exist at the core of black holes, which are areas of intense gravitational pressure. In the first second after the Universe began, the surrounding temperature was about 5.5 billion Celsius. After its initial appearance, it apparently inflated (the "Big Bang"), expanded and cooled, going from very, very small and very, very hot, to the size and temperature of our current universe. It continues to expand and cool to this day and we are inside of it.

[3] The Big Bang theory is the result of several important observations. In 1927, Edwin Hubble first observed that:

- The light from all the distant galaxies is red-shifted.
- The further away the galaxy the bigger the red-shift.

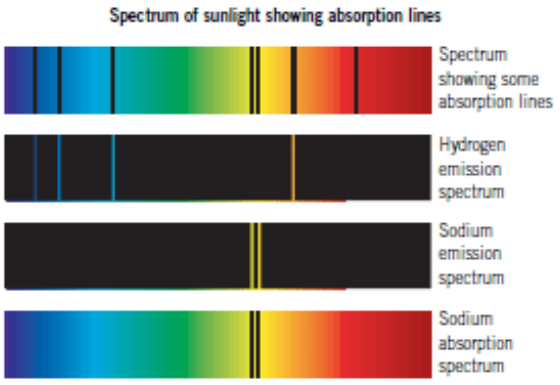
This means:

- All the distant galaxies are moving away from us.
- The further away the galaxy, the faster it is moving away.

**Red-shift**

For visible light, red has the longest wavelength and violet the shortest. If the wavelength is longer than expected this is called a **red-shift**.

If a source of waves is moving away the wavelength appears longer. A red-shift in the light from a star shows that the distance between us and the star is increasing. The bigger the red-shift, the faster the star is moving away.




[4] We would not see these patterns in the red-shifts just because we, or the galaxies, are moving through space, but it is what we would see if space was expanding.

This is why scientists think we live in an expanding Universe. The Universe is everything that exists. There is nothing outside the Universe – not even empty space.

[5] If the Universe is expanding, then one can assume that the galaxies that compose our Universe were once much closer together than they are now. By simply measuring how far apart galaxies are and how fast they are moving, we determine the Hubble Constant (estimates range from 50 to 100 km/s per kiloparsec*). The Hubble Law states that the recessional velocity** of a distant galaxy is proportional to its distance from us. It is very easy to determine the recessional velocity of galaxies; on the other hand, their current positions are difficult to measure. The distance to the galaxy is quite hard to measure, but can be estimated from its apparent angular size or by the brightness of objects in it such as supernovae.

[6] If we run the expansion process backward, we get two results.

- The first is that it probably took approximately 15 billion years for the Universe to grow to its present size.
- Second, the Universe must have begun its expansion in an awesome event that astronomers call the Big Bang.

[7] 1__The Big Bang Theory started as a hypothesis – a suggested explanation created to account for the data. 2__It was the CMBR. 3__The Big Bang Theory was the only theory that could account for it, so this evidence led to the theory being accepted by most scientists. 4__Scientists then used it to make a prediction. 5__It would come from all parts of the Universe. 6__Scientists called this the **cosmic microwave background radiation** (CMBR). 7__They said that the Big Bang would have produced radiation that, by now, would be found in the microwave region*** of the spectrum. 8__They were using a radio telescope and could not account for an annoying microwave signal that seemed to come equally from all directions. 9__Scientists began searching for the CMBR and in 1965 two scientists, Arno Penzias and Robert Wilson, discovered it accidently.

_____

* A distance of 1000 parsecs (3262 light-years) is commonly denoted by the kiloparsec (kpc). Distances expressed in parsecs (pc) include distances between nearby stars.

** Recessional velocity can be calculated according to the formula:

$$v = H_0 D$$

where $H_0$ is the Hubble constant, $D$ is the distance, and $v$ is the recessional velocity, generally measured in km/s.

*** Microwave region - микроволновый диапазон, диапазон сверхвысоких частот

**2. Try to match each term with its definition.**

| | |
|---|---|
| Recessional velocity | 1. an exploding star that produces an extremely bright light |
| The Hubble constant | 2. a belief that there was an explosion 15 billion years ago which caused the universe to begin to exist |
| parsec | 3. the study of the origin and nature of the universe |
| Supernova | 4. the speed of receding or moving away from an observer. |
| Cosmology | 5. a unit of distance used in astronomy, equal to about 3.26 light years (3.086 × 1013 kilometres) |

| | |
|---|---|
| a radio telescope | 6. a very large piece of equipment that receives and records the radio waves that come from stars and other objects in space |
| The Big Bang theory | 7. the ratio of the speed of recession of a galaxy (due to the expansion of the universe) to its distance from the observer. |
| Singularity | 8. the force that causes objects to move towards each other |
| Gravitation | 9. the process of increasing in size and filling more space |
| Expansion | 10. a point at which a function takes an infinite value, especially in space–time when matter is infinitely dense |
| Black hole | 11. an area in outer space where the force of gravity is so strong that light and everything else around it is pulled into it |

**3. Identify the reason.**

**A.** Why does the author say that the origin of the universe is one of the greatest questions in science? (Para 1)

1. The Big Bang theory is still unclear.
2. There are many other theories explaining the origin of the universe.
3. Even Edwin Hubble could not resolve this problem.

**B.** The name of Edwin Hubble is mentioned in Para 3 because:

1. He had the most powerful telescope at that time.
2. He used his knowledge about the physics of visible light.
3. He created the Hubble constant.

**C.** According to Para 7, the Big Bang theory was accepted by most scientists because:

1. Everybody respected the opinion of Penzias and Wilson.
2. Scientists predicted long time ago that the Big Bang theory was the only right theory.
3. Penzias and Wilson discovered some evidence to prove the theory.

**4. Decide if these statements are true or false.**

1. If a source of waves is moving away, the wavelength appears shorter.
2. The only thing that exists outside the Universe is empty space.
3. The further away the galaxy, the slower it is moving away.
4. It is believed that the galaxies composing the Universe used to be much closer together than they are now.
5. Cosmic microwave background radiation didn't prove the Big Bang theory.

**5. Choose three statements which better summarize the content of the article.**

- The Big Bang theory is one of the most reliable theories explaing the origin of the universe.
- The Hubble Law is very complicated.
- The theory was developed not at once.
- Stephen Hawking have made a great contribution to the development of the Big Bang theory.
- The Big Crunch must follow the Big Bang at some point of time in the future.
- The theory was based not only on theoretical knowledge, but also on practical observations.

**6. Answer the questions.**

1. What is a red-shift?

2. What relationship exists between the speed of the galaxies moving apart and their initial distance from one another? Name this Law.
3. What is harder for the astronomer to measure: a galaxy's red-shift (indicating recessional velocity) or its distance from Earth?
4. How long ago was the Big Bang?
5. What did the Big Bang Theory predict that scientists started to search for?
6. Why is it believed that we live in an expanding Universe?

VOCABULARY

**7. Match the words with their explanations.**

| | |
|---|---|
| 1. to account for (something) | a. the rate or speed at which an object is moving away, typically from Earth |
| 2. to expand | b. to the same degree |
| 3. a pattern | c. clear to understanding, open to view |
| 4. recessional velocity | d. to give reasons for, to explain |
| 5. current | e. to make or become greater in extent, volume, size, or scope; increase |
| 6. equally | f. a star that explodes catastrophically due to instabilities of its nuclear fuel or gravitational collapse |
| 7. apparent | g. a form or model proposed for imitation |
| 8. supernova (pl -*ae*) | h. most recent; up-to-date |

**8. Complete the sentences using correct forms of the following words:**

*to account for (something), to expand, pattern, recessional velocity, current, equally, apparent, supernovae.*

1. What is your opinion of the _____ state of modern art, in this country and internationally?
2. _____ is measured by distance from the Earth multiplied by the Hubble constant.
3. A great proportion of primary cosmic rays comes from _____.
4. From the beginning, it was _____ that she was not an ordinary child.
5. Both features allow you to specify a _____ that controls the form of data.
6. It is _____ important to install these updates, especially for web applications.
7. The liquid _____ and contracts with changes in temperature.
8. How do you _____ the fact that the amount of particles is still rising?

**9. For each set find one word mentioned in the text that will fit all sentences (it must be one word but may be different forms and parts of speech)**

**A.**

a) The time of the annihilation process is much less than the period of one _____.
b) It's a spacious, clean, kitchen outfitted with every appliance from _____to dish washer
c) Such a signal has harmonics at 1-MHz intervals throughout the _____region, all of which have the same phase at the reference intervals.

**B.**

a) It is fun to see a pirate tavern where the bar fights are just the _____background noise.
b) Her best friend and _____companion is Brent.

c) Since its differences are the same as the Fibonacci series differences, we can add or subtract a _____to the Fibonacci series.
d) The diffraction _____for the diffractometer was calculated using a grating with 0.1 turn spacings.

**C.**

a) There was only £50 in his bank _____.
b) Electronic goods _____for over 30% of our exports.
c) I have two _____on Facebook: my personal one and for business.
d) The increase in carbon dioxide emissions may _____for changes in the climate.
e) The study aims to give an _____of modern attitudes towards democracy.

**D.**

a) Rudolfo works the day _____.
b) The government has _____its attention away from the fight against crime.
c) The wall is _____a couple of centimeters every year.
d) Just press a _____key on a computer keyboard when you want to write a capital letter.

**10. Find a synonym to the first word.**

Infinitely: continuously / very much / always / with no limit
Current: electrical / high-quality / present-time / fast
To account for: to count money / to be the reason for / to prove smth / to detect

**11. Use the words given in bold to form a word that fits in the space in the same line.**

The 20th century was a boon for cosmology. _____ with Einstein, scientists now believed in an _____ expanding universe based on the rules of _____. Edwin Hubble then _____ the scale of the universe by proving that “spiral nebulae” observed in the night sky _____actually other galaxies. By showing how they were red _____, he also demonstrated that they were moving away, proving that the _____ really was _____. This in turn, led to the Big Bang theory which put a starting point to the universe and a _____ end.

1. **begin**
2. **finite**
3. **relative**
4. **demonstration**
5. **be**
6. **shift**
7. **universal**
8. **expansion**
9. **possibility**

**12. Translate the text into English.**

**Dark Energy**

In 1996, observations of very distant supernovae required a dramatic change in the picture. It had always been assumed that the matter of the Universe would slow its rate of expansion. Mass creates gravity, gravity creates pull, the pulling must slow the expansion. But supernovae observations showed that the expansion of the Universe, rather than slowing, is accelerating. Something, not like matter and not like ordinary energy, is pushing the galaxies apart. This "stuff" has been dubbed dark energy, but to give it a name is not to understand it. Whether dark energy is a type of dynamical fluid, heretofore unknown to physics, or whether

it is a property of the vacuum of empty space, or whether it is some modification to general relativity is not yet known.

LISTENING: DARK MATTER

**13. Read the introduction.**

All the stars in a spiral galaxy rotate around a center – but to astronomers, the speed that each star travels wasn't making sense. Why didn't stars slow down toward the edges as expected? Don Lincoln explains how a mysterious force called dark matter is (possibly) the answer – and why the search for an answer matters.

**14. Make sure you understand these phrases:**

- this observation was devastating
- to move leisurely
- galaxies should have torn themselves apart
- other options have been ruled out

**15. Listen to or watch the video and answer the questions. Only one answer is correct. Read the questions first.**

*1) The fact that we can see so many spiral galaxies using our telescopes tells us that they are both:*

A spontaneous and short-lived

B common and stable

C hot and dangerous

D magnetic and bright

*2) Stars at which distance from the center of the galaxy move the fastest according to predictions?*

A Those closest to the center

B Those in the middle

C Those on the outer edge

D All the stars move at the same speed

*3) The observation that the stars located far away from the center of a galaxy move too quickly was devastating because scientists began to doubt:*

A Newton's Theory of Gravity

B Theory of Motion

C mathematical calculations of mass of galaxies

D all mentioned above

*4) What's the best description of dark matter?*

A A watery substance that surrounds most galaxies that is unaffected by gravity and visible to visible light and all other form of electromagnetic radiation

B A vacuum that surrounds some galaxies that is affected by gravity and invisible to ultraviolet light and most other form of electromagnetic radiation

C A cloud that surrounds most galaxies that is affected by gravity and invisible by visible light and all other form of electromagnetic radiation

D A weighty dust that surrounds most galaxies that is affected by gravity and visible to visible light and most other form of electromagnetic radiation

*5) Which is not true about dark matter?*

A Its name comes from its inability to emit or absorb light

B It adds to the mass of the galaxy it surrounds

C It has not yet been directly observed

D The dark matter hypothesis has been proved beyond all reasonable doubt

**16. Test yourself.**

1. How old is the universe? How big is the universe? In what sense is the universe expanding?
2. What is a galaxy? Where is the Earth in the Milky Way galaxy?
3. What is the closest galaxy like our own, and how far away is it?
4. Galaxy names are identified by a group of letters and numbers. What do they stand for?
5. Why do astronomers study galaxies in ultraviolet light?
6. How do astronomers measure the distances to galaxies?
7. Who is Edwin P. Hubble and what has he to do with galaxies?
8. What are constellations?
9. Has Hubble found planets around other stars?
10. How is the color of a star cluster linked to its age?
11. What is a supernova, and what can it tell us about the universe?

MINI-GRAMMAR

PASSIVE AND ACTIVE VOICE

**Forms of passive**

The passive voice is not a tense itself. But for transitive verbs each tense, as well as other verb forms such as infinitives and participles, can be produced in the passive voice. Some of the more complicated tenses (mostly perfect continuous) are rarely used in the passive, but they are possible.

The universal formula of the passive is:

**(TO BE) + $V_3$**

Here are some examples of the passive voice with many of the possible forms using the verb *break*:

| | |
|---|---|
| infinitive | *to be broken* |
| perfect infinitive | *to have been broken* |
| participle | *Broken* |
| perfect participle | *having been broken* |
| gerund | *being broken* |

INFINITIVE FORMS

| Tense | Active | Passive |
|---|---|---|
| Present Simple | (to) give | (**to) be given** |
| Present Continuous | (to) be giving | **(to) be being given** |
| Present Perfect | (to) have given | **(to) have been given** |
| Present Perfect Continuous* | (to) have been giving | **(to) have been being given** |

**The Passive Voice is used:**

1. when the agent is unknown or unimportant (деятель неизвестен, неважен)

*A big company will build an experimental solar power plant in the Australian desert. → An experimental solar power plant **will be built** in the Australian desert.*

2. when the agent is obvious from the context or from general knowledge (деятель очевиден)

*The professor delivers lectures on physics on Friday mornings. → The lectures on physics are delivered on Friday mornings.*

3. when the speaker does not want to mention the agent to be more polite in a formal situation (из вежливости в формальной ситуации деятель не упоминается)

*Will you grant our application for a new stage of experiments? → **Will** our application for a new stage of experiments **be granted**?*

4. to be vague about who is responsible, or not to blame a specific person (не обвинять конкретного человека, расплывчато говорить о деятеле)

*John has made mistakes on this project. → Mistakes **have been made** on this project.*

5. to report impersonal or general feelings, opinions, beliefs, decisions (выражать общие ощущения, мнения, решения)

*They report that she came back. → She **is reported to** have come back.*

*People think that Newton was a great scientist. → Newton **is thought to** be a great scientist.*

*We expect you to complete the project. → You **are expected to** complete the project. → We expect the project **to be completed**. → The project **is expected to be completed**. (double passive)*

6. to focus on the topic more, not the agent (делать упор не на деятеля, а больше на действие)

*Researchers at the University of Toronto first discovered insulin in 1921. → Insulin **was first discovered** in 1921 by researchers at the University of Toronto.*

7. to describe rules, processes, methods and procedures (при описании правил, процессов, методов, процедур)

*The sodium hydroxide **was dissolved** in water. This solution **was** then **titrated** with hydrochloric acid.*

> ***Note!***
>
> *Over the past several years, there has been a movement within many science disciplines away from passive voice. Scientists often now prefer active voice in most parts of their published reports, even occasionally using the subject "we" in the scientific research papers.*

**The Passive Voice is NOT used:**

1. with intransitive verbs, that is the verbs that do not take an object (с непереходными глаголами)

*We **arrived** to the conference very late. ~~We were arrived to the conference very late.~~*
***Did** you **sleep** well? ~~Were you slept well?~~*
*The plane **has landed**. ~~The plane has been landed.~~*

2. with certain state verbs even if they are transitive (с некоторыми переходными глаголами выражающими состояние)
   *belong принадлежать, have* иметь (own, possess)*, lack не иметь достаточно, be быть, pretend притворяться, seem казаться, resemble напоминать, suit подходить, appear казаться)*.

*Joanne **has** two major articles. ~~Joanne is had two major articles.~~*
***Does** this theory **belong to** you? ~~Is this theory belonged to you?~~*
*The test **seems** to be quite difficult. ~~The test is seemed to be quite difficult.~~*

3. with active verbs with a passive meaning (с активными глаголами в пассивном значении)

*The company's new phone **doesn't sell** as well as the last one. (телефон не продаётся)*
*The sign on the door **read** "No entry". (знак читается как, говорит нам)*
*The trousers have been mended, and now the hole **doesn't show**. (дырка не заметна, не видна)*

4. with certain verbs followed by (object) + infinitive/bare infinitive, such as *want (him to leave), refuse (to leave), let (him leave)* etc. (некоторые глаголы в составе инфинитивной конструкции)

*The teacher **let** us do the experiment. ~~The teacher was let us do the experiment.~~*

*I **refuse** to answer your question. ~~Your question is refused to answer.~~*

5. with *have + noun* to describe an action, e.g. *have a shower, have lunch, have a good time etc.* (глагол have выражающий действие, а не состояние)

*John **is having** lunch. ~~Lunch is being had by John.~~*

**17. Identify the passive form of the verb and translate into Russian.**

1. Methods employed in solving a problem are strongly influenced by the research objective.
2. As data are changed, how are outputs affected?
3. This paper was shortly followed by another by the same author.
4. Any statement which must be referred to by any other statement in the program must be identified by a "statement number".
5. The inward component is not affected by any of these treatments.
6. These rules were arrived at independently.
7. Often objects can be defined and dealt with independent of their parameters.
8. A printer gets assigned temporally to a user as his own whilst he uses it.
9. Mercury becomes contaminated and cannot be reused.
10. The output gets subtracted from the input signal.

## Part III “Space Exploration”

*“God not only plays dice, but also sometimes throws them where they cannot be seen.”*

Stephen Hawking, 1977

LEAD-IN: DISCUSSION

1. What is your opinion of science fiction series and films like ET, Alien, Star Trek, Star Wars?
2. Have you ever taken an astronomy course? If so, tell about something you learned. Have you ever used a telescope? What did you look at?
3. Would you like to be an astronaut? Why or why not?
4. When do you think people will visit Mars? What do you think they will find there?
5. Methods of finding out about the Solar System and what is beyond it are: to use telescopes both ground-based and in orbit, to send unmanned space probes, to send manned spacecrafts. In your opinion, which method is the most dangerous? the cheapest? the most effective?

LISTENING: THE INTERVIEW WITH STEPHEN HAWKING

**1. Answer the questions.**

Do you know who Stephen Hawking is?

Do you think people will destroy the Earth one day? How will that happen?

Do you believe that people may die out just like dinosaurs?

Is it now possible for people to move to another planet?

**2. Listen to or watch a video of an interview with Stephen Hawking* recorded on March 7, 2008 and answer the following questions.**

_____

* Stephen Hawking is a British theoretical physicist, cosmologist, and author. Despite being almost completely paralyzed and communicating through a speech generating device, Hawking remains one of the world's foremost theoretical physicists and has contributed greatly to our understanding of the universe.

**Questions:**

1. What is going to be the greatest achievement of scientists since the Theory of Relativity?

2. What does Stephen Hawking worry about?

a) about the future of the Universe because it can explode one day
b) about the life on Earth because people can destroy themselves
c) about the future of the Universe because it will continue to grow forever
d) about the life of the human race because there wouldn't be enough resources on Earth

3. What does human survival depend on?

4. What should people do by the end of this century?

a) invent the Theory of Everything and it will make life easier
b) find another place to live beside Earth

5. What is the problem that people are not solving efficiently nowadays?

a) inventing the Theory of Everything
b) climate change
c) finding life on Mars
d) researching the Dark matter and energy

6. Does Stephen Hawking believe that people are going to survive?

**LEAD-IN**

**1. Discuss the questions:**

What do you think is a space elevator and how could it be used?

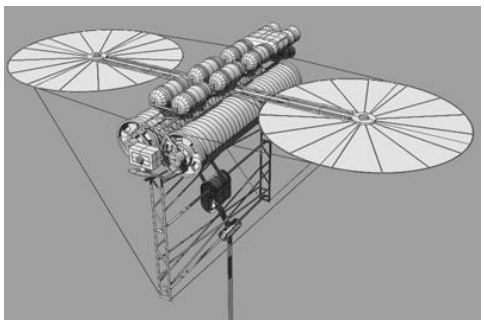
How do you think a space elevator would work?

What technical challenges would it face?

How seriously do you think the concept of space elevators is being taken at present?

**READING**

Photo courtesy LiftPort Group: satellite at GEO



## Space Elevators

[1] When the Space Shuttle Columbia lifted off on April 12, 1981, from Kennedy Space Center, to begin the first **space shuttle** mission, the dream of a **reusable** spacecraft was realized. Since then, NASA has launched more than 100 missions, but the price of space missions has not changed. Whether it is the space shuttle or the non-reusable Russian spacecraft, the cost of a **launch** is approximately $22,000 per kg.

[2] But many years prior to these events, in his 1979 novel, *The Fountains of Paradise*, Arthur C Clarke had written about an elevator **connecting** the earth's surface to space. Three decades later, this science-fiction concept is preparing to take off in the real world. NASA has launched the Space Elevator Challenge, a

competition with a generous prize, and several teams and companies are working on serious research projects aimed at winning it.

[3] As its name suggests, a space elevator is designed to **raise** things into space. **Satellites**, components for space ships, supplies for astronauts in space stations, and even astronauts themselves are examples of payloads that could be **transported** into orbit without the need for explosive and environmentally unfriendly rockets. A new space transportation system like this could make travel to geostationary Earth orbit (GEO) a daily event and transform the global economy. As researchers predict, **space elevator** would be able to carry cargo and humans into space at a price of only about $220-$880 per kg.

[4] However, the altitude of orbital space – a colossal 35,790 km above the earth – is a measure of the challenge facing engineers. How could such a height be reached? The answer is by using an incredibly strong and lightweight **cable**, strong enough to **support** its own weight and a heavy load. It would be **attached** to a **base station** on earth at one end and a satellite in geostationary orbit (fixed above a point on the equator) at the other. Lift vehicles would **ascend** and **descend** the cable, **powered** by electromagnetic force and **controlled** remotely. The design of such a cable is still largely theoretical but current material that could be used for this purpose is **carbon nanotubes**.

[5] Carbon nanotubes have the potential to be 100 times stronger than **steel** and are as **flexible** as plastic. The strength of carbon nanotubes comes from their unique structure. Once scientists are able to make **fibers** from carbon nanotubes, it will be possible to create **threads** that will form the **ribbon** for the space elevator.

[6] A ribbon could be built in two ways. First, long carbon nanotubes -- several meters long or longer -- would be braided into a structure resembling a rope. As of 2005, the longest nanotubes are still only a few centimeters long. The second way is to place shorter nanotubes in a polymer matrix. Current polymers do not bind well to carbon nanotubes, which results in the matrix being pulled away from the nanotubes when placed under tension. The ribbon would serve as the tracks of a sort of railroad into space. Mechanical lifters would then be used to climb the ribbon to space.

[7] The space elevator could replace the space shuttle as the main space vehicle, and be used for satellite deployment, defense, tourism and further exploration. To the latter point, a spacecraft would climb the ribbon of the elevator and then would launch toward its main target once in space. This type of launch would require less fuel than would normally be needed to break out of Earth's atmosphere. Some designers also believe that space elevators could be built on other planets, including Mars.

**2. Try to give a definition for each term. You may use the text or a dictionary.**

- space elevator
- cable
- base station
- satellite
- geostationary orbit
- lift vehicles
- carbon nanotubes

**3. Choose three statements which better summarize the content of the article.**

- Geostationary orbit is the place for most earth's artificial satellites.
- Shuttles are reusable but still very expensive.
- Space elevators would be much more efficient than space shuttles.
- The concept of a space elevator in not as new as it may seem.
- The only technological challenge is to create a long ribbon made of carbon nanotubes.
- There are two ways to build a ribbon.

**4. Answer the questions.**

1. Why space shuttles are not very effective?
2. How did the idea of a space elevator appear?
3. What is a space elevator? Tell about its components.
4. How will the system work?
5. What materials must be used?
6. How could a ribbon be built?
7. How could a space elevator be used in the future?

VOCABULARY

**5. Match the verbs from the text to its synonym.**

| | |
|---|---|
| 1. connecting | a) carried (objects, over a distance) |
| 2. raise | b) hold something firmly / bear its weight |
| 3. transported | c) climb down |
| 4. support | d) provided with energy / moved by a force |
| 5. attached | e) joining |
| 6. ascend | f) driven / have movement directed |
| 7. descend | g) flat cable |
| 8. powered | h) climb up |
| 9. controlled | i) lift / make something go up |
| 10. ribbon | j) fixed |

**6. For each set find one word mentioned in the text that will fit all sentences (it must be one word but may be different forms and parts of speech)**

**A.**

a) Find out why METRO Cash & _____ is the world wholesale leader.
b) British police officers don't normally _____guns.
c) It is a cable _____electricity to nearby homes.

**B.**

a) He has amazing _____of concentration.
b) China has become a major economic _____in Asia.
c) A new vehicle is _____by gas.

d) Solar _____is an environmentally friendly type of energy.

**C.**

a) Our head company is _____in Osaka.
b) A _____is one of the four places on a baseball that a player must touch in order to score points.
c) The statue stands on a large round _____.

**7. Use the words given in bold to form a word that fits in the space in the same line.**

Cable section

_____ , the main technical problem has been considered the _____ of the cable to hold up, with tension, the weight of itself below any given point. The greatest _____ on a space elevator cable is at the point of _____ orbit, 35,786 km (22,236 mi) above the Earth's equator. This means that the cable material must be _____ enough to hold up its own _____ from the surface up to 35,786 km (22,236 mi). A cable which is thicker in cross section at that _____ than at the surface could better hold up its own _____ over a longer _____ . How the cross section area tapers from the maximum at 35,786 km to the _____ at the surface is therefore an important design factor for a space _____ cable.

1. **history**
2. **able**
3. **tense**
4. **station**
5. **strength**
6. **weigh**
7. **high**
8. **weigh**
9. **long**
10. **minimize**
11. **elevate**

**8. James, an engineer, is preparing a talk on space elevators. Look at his short notes and complete them with a missing word.**

**Space Elevators**

Challenge of connecting a 1)_____ to earth by cable is significant.

To support its own weight, and be securely 2)_____ at each end, cable would need phenomenal strength-to-weight ratio.

How could vehicles be 3)_____ into space, up cable?

Self-contained energy source problematic, due to 4)_____ (heavy fuel or batteries required to power vehicle).

Two possible ways round problem:

First. Transmit electricity 5)_____. But technique is only at 6)_____ stage.

Second. Solar power. But would only allow vehicle to 7)_____ slowly. Not necessarily a problem, as car could be controlled 8)_____, allowing it to transport 9)_____ unmanned.

RESEARCH PAPER WRITING: AIMS AND RESULTS

## A. Expressing aims

| Key word | Useful phrases | Comment |
|---|---|---|
| **goal** | *to accomplish, achieve a goal; to have smth as a goal* | |
| **intention** | *with the intention of Ving; have no intention of Ving/to V* | verb: *to intend to do smth* |
| **motive** | *motive for Ving* | general noun: *motivation* |
| **objective** | *to meet, achieve objectives; main/primary objective* | what you plan to do |
| **priority** | *top priority; to set/establish/identify priorities* | a list of important things |
| **purpose** | ***for the purpose of Ving*** | *on purpose* = deliberately |
| **strategy** | *to develop, follow, plan a strategy* | detailed plan for success |
| **target** | *to achieve, reach a target* | level or situation you want to achieve |
| **aim** | *to achieve /fulfill your aims* | the thing that you hope to achieve by doing something |

## B. Developing ideas

| Key word | Useful phrases | Comment |
|---|---|---|
| **hypothesis** | *to be based on a hypothesis; to formulate, to confirm a hypothesis* | plural form: *hypotheses* |
| **research** | *to do, conduct, carry out research; research on/into* | uncountable (no "a" article, no plural form: *Her latest work confirms the findings of earlier ~~researches~~.)* |
| **definition** | *a clear definition; to broaden/widen a definition* | verb: *to define* |
| **method** | *an effective /efficient method; to apply, develop, provide, use a method* | |
| **criteria** | *to meet, fulfill criteria* | the plural form of *criterion* is *criteria* |
| **application** | *practical application* | |
| **contribution** | *to make a contribution to smth; a great, important, significant, useful contribution* | verb: *to contribute* |
| **problem** | *to solve a problem* | |

| | | |
|---|---|---|
| **issue** | *to raise an issue; a big, controversial issue about/around* | |
| **challenge** | *to face a challenge* | adjective: *challenging*;<br>verb: to challenge |

**C. Analyzing results**

Academic texts often include sections which deal with the analysis of data. In analyzing a controversial issue, the writer may need to **come to / reach a conclusion** about the **advantages** and **disadvantages** of a particular **course of action**. The writer may, for instance, conclude that the **benefits outweigh** the **drawbacks** or vice versa. An analysis may be a matter of **weighing up** both **sides of an argument, taking into account** all the **relevant aspects** of the issue and discussing all the **points raised** by the research. When analyzing the results of a scientific experiment, the writer is likely to need to **take into consideration** a range of **variables**. In their analysis scientists try to **deduce** as much as they can from their data, **drawing conclusions** that are **soundly based** on their results.

**15. Match a key phrase from the text above with its explanation.**

| Key words | Explanation |
|---|---|
| course of action (1) | (a) are of more importance than |
| to outweigh (2) | (b) completely, firmly |
| drawbacks (3) | (c) consider |
| to weigh up (4) | (d) disadvantages |
| relevant aspects (5) | (e) idea, opinion or piece of information that has been presented in relation to the topic |
| points (6) | (f) important parts, features (of a problem or situation) |
| variables (7) | (g) number, amount or aspect of a situation which can change |
| to deduce (8) | (h) reach an answer by thinking carefully about the known facts |
| soundly (9) | (i) think carefully about |
| to take into account (10) | (j) way of doing something |

**16. Here are some other sentences relating to analyses. Translate them into Russian using explanations in brackets.**

1. The survey provided some useful **insights into** the problem. [points that help us to understand more clearly]
2. The results **point to** an interesting trend. [show, indicate]

3. **On the basis of** the application data we would **predict** continuing interest of perspective students in astrophysics. [say something will happen in the future]
4. We found that women **constitute** 70% of the workforce in the university. [account for]
5. We began with a **critical** review of the scientific literature in the field. [giving opinions]
6. We are reaching a **critical** period in terms of global climate change. [very important]
7. The astronaut is in a **critical** condition. [serious]

**17. Complete the expressions with a word which can combine with all the words given.**

1. _____ moment / review / comments
2. come to / draw / reach a _____
3. come down on one / be in favor of one / see both _____ (s) of an argument

**18. Introduce your current research paper. Write in short about its aim and main ideas using phrases from sections A and B.**

WRITING: FOR AND AGAINST ESSAY

**19. Write an essay concerning the topic.**

*No human has landed on Mars to this day. Why should people succeed in this? Is it best to send unmanned space probes or a manned mission to find out about Mars?*

**Use the plan:**

Paragraph 1: introduce the question and express your point of view

| | |
|---|---|
| to accomplish, achieve a goal | to set/establish/identify priorities |
| to have smth as a goal | to develop a strategy |
| to meet /achieve objectives | to achieve/ reach a target |
| the main/primary objective | to achieve /fulfill your aims |

Paragraph 2: mention that the problem is controversial and present a few ideas that you do not support/disadvantages (see useful phrases below)

Paragraph 3 (+/- 4): present ideas that you support/advantages, provide a few examples if possible

| | |
|---|---|
| to be based on a hypothesis | to make a contribution to smth |
| to formulate, to confirm a hypothesis | to solve a problem |
| to do/ conduct/ carry out research on | to raise an issue |
| to apply, develop an effective method | a big, controversial issue |
| to meet/ fulfill criteria | to face a challenge |
| practical application | |

Paragraph 5: analyze the results and write a conclusion (see useful phrases below)

| | |
|---|---|
| to come to / reach a conclusion | to take into account the points raised |
| advantages and disadvantages | to take into consideration a range of variables |
| benefits outweigh the drawbacks | to draw conclusions |
| to weigh up both sides of an argument | |

Look through some ideas to help you build your own opinion. **Do not plagiarize them!**

| **For a manned mission** | **Against** |
|---|---|
| • humans would easily be able to outperform robotic explorers in precision and accuracy<br>• humans are intelligent creatures – less time to analyze data<br>• unmanned mission must be planned and programmed thoroughly a long time ahead – no possible changes on the way<br>• unmanned missions do not inspire people<br>• people want to gain popularity and fame | • cost less money<br>• a manned mission could contaminate Mars by introducing earthly microbes<br>• we have a lot of information about Mars without human travelling there<br>• harmful conditions would kill humans<br>• limitation of food, water and other supplies<br>• low gravity of Mars would affect humans' organism<br>• instant cosmic rays and radiation<br>• instabilities of psychological state of isolated humans |

SPEAKING

**15. Express your opinion.**

1. When the first rockets were sent up into space, or the first manned flights started, it was big news. Nowadays, unless associated with a tragedy, space-related news seems to be old hat. Why do you think that is?
2. Nowadays space tourism is just starting up. How would you feel if you won a trip to the international space station?
3. What do you think about the value of space exploration?
4. Can you think of any inventions or benefits which have resulted from space exploration?
5. In what ways would the world be different if there were no satellites in orbit around the earth?
6. What do you think of the idea that we could escape into space if (or when) the earth becomes uninhabitable for whatever reason?

**Unit 2 Vocabulary List**

(inter)stellar

a crew

a fund-raising campaign

a plane (not an airplane)

a rover

a satellite

a stepping stone

an entrepreneur

an outpost

anchor

apparent

applicable

approximately

as a whole

bubble

bulk

celestial

clockwise

considerable

counterclockwise

criterion (pl criteria)

critical

scattered (disk)

significant

solar

spacecraft

substantial

supernova (pl supernovae)

terrestrial

thread

to accomplish a goal

to account for (something)

to achieve your aims/ a target/a goal

to apply a method

to ascend

to attach

to be comprised of

to come to / draw a conclusion

to descend

to develop a strategy

to do, conduct, carry out research

to expand

to expose

to face a challenge

| | |
|---|---|
| current | to float |
| drawback | to formulate a hypothesis |
| dwarf (pl dwarves) | to fulfill your aims |
| enormous | to make a contribution |
| far-fa/urther -the fa/urthest | to meet an objective |
| feasible | to meet criteria |
| giant | to orbit (smth) |
| immense | to outweigh |
| large/small-scale | to point to smth |
| lunar | to raise an issue |
| massive | to reach a target |
| objective | to revolve |
| offshore/onshore base station | to rise-rose-risen |
| on the basis of | to rotate |
| payload | to set/establish priorities |
| preliminary (work, results) | to solve a problem |
| reasonable | to stretch |
| recessional velocity | to take into account/consideration |
| ribbon | to weigh up both sides of an argument |
| rope | variables |

**Topics for speaking:**

1. The Solar System
2. The Big Bang
3. The Red-Shift
4. Dark Matter and Energy
5. Mars Exploration
6. Space Elevators

# Unit 3: MATTER IN MOTION

## Part I "NEWTON'S LAWS OF MOTION"

**1. In pairs or small groups, discuss the questions:**

1) What exactly is speed?
2) What is velocity?
3) What is acceleration?

**2. Do you remember Newton's laws of motion?**

1) Every action of a force produces an equal and opposite reaction.
2) Bodies move in a straight line with a uniform speed, or remain stationary, unless a force acts to change their speed or direction.
3) Forces produce accelerations that are in proportion to the mass of a body (*F= ma*)

**3. Match the terms with their definitions.**

| | |
|---|---|
| 1. Vector | a. a force that stops something moving or makes it move more slowly |
| 2. work | b. the form of energy that an object gains as it is lifted |
| 3. resistance | c. the resistance of one surface to another surface or substance moving over or through it |
| 4. potential energy | d. a quantity that has both size and direction |
| 5. power | e. the quantity of movement of a moving object, measured as its mass multiplied by its speed |
| 6. momentum | f. the use of force to produce movement |
| 7. kinetic energy | g. the strength of energy contained in something |
| 8. friction | h. energy produced by movement |

**4. Fill in the gaps with the words from the list.**

| | | | |
|---|---|---|---|
| *measure* | *pairs* | *slow* | *can* |
| *speed* | *unbalanced* | *direction* | *turn* |
| *can't* | *change* | *effects* | *balanced* |
| *pushes* | *shape* | *pulls* | |

**Force and Movement**

1. Forces are nearly _____ and _____.
2. Forces _____ be seen, but the _____ of a force _____ be seen.
3. They usually act in _____ .
4. They always act in a certain _____ .
5. A newton meter is used to _____ forces.
6. Forces can make objects do five things: _____ up, _____ down, _____ direction, _____ , change_____ .
7. _____ forces produce no change in movement.
8. _____ forces change the speed and or direction of moving objects.

**5. Decide if these statements are true or false.**

1. Velocity describes both the speed and direction of an object.
2. Velocity can't be negative.
3. Deceleration is a negative acceleration.
4. Quantities that have magnitude and direction are called vectors.
5. Speed can be a negative number.
6. Resistance decreases as the speed of the object increases.
7. In a vacuum objects continue to fall with acceleration due to gravity of 10 $m/s^2$
8. There is always a force in the direction of movement.
9. Weight is a force, which is measured in newtons (N).
10. An object has different mass on the Earth, the Moon and in outer space.
11. The total momentum of two objects before collision or explosion is different from the total momentum after.

**6. Read and complete the text using the words below and arrange the sentences of Paragraph 2 in the right order**.

NEWTON'S LAWS of MOTION

[1] Isaac Newton was one of the most prominent and influential scientists of all time. He helped to invent calculus, explained gravity and identified the constituent colors of white light. His three laws of motion describe why a golf ball follows a 1) _____ path, why we are pressed against the side of a cornering car and why we feel the force through a baseball bat as it strikes the ball.

[2] (1- … )Then, when the university was closed for an outbreak of plague, Newton took the first steps to developing his three laws of motion. (2- …) An average student at Cambridge in the 1660s, Newton began by reading the great works of mathematics. (3- …)It took him highly inquisitive character to understand some of the most seemingly simple yet profound aspects of our world, such as how a thrown ball curves through the air, why things fall down rather than up and how the planets move around the Sun. (4- …) Through them he was drawn away from civic law into the laws of physics. (5- …) Newton, who lived in the 17th century, is considered one of the foremost intellects of science.

[3] Borrowing Galileo's principle of inertia, Newton formulated his fist law. It states that bodies do not move or 2) _____ their speed unless a force acts. Bodies that are not moving will remain stationary unless a 3) _____ is applied; bodies that are moving with some constant speed keep moving at that same speed unless acted upon by a force. A force supplies an acceleration that changes the velocity of the object. 4) _____ is a change in speed over some time.

[4] This is hard to appreciate in our own experience. If we throw a hockey puck it skims along the ice but eventually slows due to friction with the ice. Friction causes a force that decelerates the puck. But Newton's first law may be seen in a special case where there is no 5) _____ . The nearest we might get to this is in space, but even here there are forces such as gravity at work. Nevertheless, this first law provides a basic touchstone from which to understand forces and motion.

[5] Newton's second law of motion relates the size of the force to the acceleration it produces. The force needed to accelerate an object is proportional to the object's mass. 6) _____

objects – or rather ones with large inertia – need more force to accelerate them than lighter objects. So to accelerate a car from standing still to 100 kilometers an hour in one minute would take a force equal to the car's mass times its increase in speed per unit time. Newton's second law is expressed algebraically as *'F= ma'*, force (*F*) equals mass (*m*) times acceleration (*a*). Turning this definition around, the second law expressed in another way says that acceleration is equal to force per unit mass. For a constant acceleration, force per unit mass is also unchanged. So the 7) _____ amount of force is needed to move a kilogram mass whether it is part of a small or large body. This explains Galileo's imaginary experiment that asks which would hit the ground first if dropped together: a cannonball or a feather? Visualizing it we may think that the cannonball would arrive ahead of the drifting feather. But this is simply due to the air resistance that wafts the feather. If there were no 8) _____ , then both would fall at the same rate, hitting the ground together. They experience the same acceleration, gravity, so they fall side by side. *Apollo 15* astronauts showed in 1971 that on the Moon, where there is no atmosphere to slow it down, the feather falls at the same rate as a geologist's heavy hammer.

[6] Newton's third law states that any force applied to a body produces an equal and opposite reaction force in that body. In other words, for every action there is a reaction. The opposing force is felt as recoil. A marksman feels the kick of the rifle against his shoulder as he shoots. The recoil force is equal in size to that originally expressed in the shove or the bullet. In crime films the victim of a shooting often gets propelled 9) _____ by the force of the bullet. This is misleading. If the force was really so great then the shooter should also be hurled back by the recoil of his gun. Even if we jump off the ground, we exert a small downward force on the Earth, but because the Earth is so much massive than we are, it barely shows.

[7] With these three laws, plus 10) _____ , Newton could explain the motion of practically all objects. Armed with these three equations he could confidently have climbed aboard a fast motorbike and sped up onto the wall of death, had such a thing existed in his day. How much trust would you place in Newton's laws? The first law says that the cycle and its rider want to keep travelling in one direction at a certain speed. But to keep the cycle moving in a circle, according to the second law, a confining force needs to be provided to continually change its 11) _____, in this case applied by the track through the wheels. The force needed is equal to the mass of the cycle and rider multiplied by their acceleration. The third law then explains the pressure exerted by the cycle on the track, as a reactionary force is set up. It is this pressure that glues the stunt rider to the inclined wall, and if the bike goes fast enough it can even ride on a vertical wall. Where Newton's laws do not hold is for things moving close to the speed of light or with very small masses. It is in these extremes that Einstein's relativity and the science of quantum mechanics take over.

| | | |
|---|---|---|
| a. backwards | e. gravity | i. change |
| b. heavy | f. curving | j. acceleration |
| c. direction | g. same | k. force |
| d. air | h. friction | |

**7. Read the text again and find the words that mean the same as the following phrases.**

a) action of one object or surface moving against another;

b) to throw sth/sb violently in a particular direction;

c) a property of matter by which it stays still or if moving, continues moving in a straight line unless it is acted on by a force outside itself;
d) added a number to itself a particular number of times;
e) the force or weight with which sth pressed against sth else;
f) to move, or push sth forward or in a particular direction;
g) a sudden movement backwards, especially of a gun when it is fired;
h) a force that stops sth moving or makes it move more slowly;
i) to begin to have control of or responsibility for sth;
j) to use power to affect sb/sth;
k) repeated many times without interruption.

**8. In pairs, discuss and write definitions for the highlighted terms from the text. Use a dictionary to help you.**

**9. Identify the reason**.

**A.** In Paragraph 4 the author says *'This is hard to appreciate in our own experience'* because:
1. In practice acceleration always changes the speed;
2. In real life friction always changes the speed or direction;
3. Only in space gravity helps its work.

**B.** On the Moon Apollo 15 astronauts demonstrated that the feather falls at the same time as a hammer because:
1. Without gravity they experienced the same acceleration;
2. Of gravity they fall at the same time;
3. There was almost no air resistance.

**C.** Newton's laws don't work for things moving at a speed of light or with small masses because:
1. Other laws work in extremes;
2. Kepler's laws are used to explain their motion;
3. The weak and the strong forces govern their motion.

**10. Indentify the purpose**.

**A.** The author states that 'the scenes in crime films when the victim of a shooting often gets propelled backwards by the force of a bullet are misleading 'because:
1. The force of a flying bullet can't be so great to hurl the victim backwards;
2. According to Newton's third law of motion the shooter should also be hurled back by the recoil of the gun;
3. The victim has much less mass than the Earth, so the force of gravitation can't be so great.

**B.** The author states that' the first law provides a basic touchstone from which to understand forces and motion' because:
1. It is the part of the second law of motion;
2. It helps to explain the behavior of objects;
3. It is the law that proved the existence of inertial systems.

**C.** The author says that' with these three laws, plus gravity, Newton could explain the motion of practically all the objects, from falling acorns to balls fired from a cannon' because:
1. He proved that these laws are able to measure and calculate the values of velocity, acceleration, different forces, mass as a unit of inertia, weight;
2. Despite the progress in science we still use these laws to design a new car or launch a spacecraft to Mars;

3. These laws explain any force exerted on an object.

**11. Choose the statement which better summarizes the content of the text.**

- Newton's three laws of motion became the foundations of quantum physics.
- Newton's three laws of motion gave the physicists the tools necessary for the beginning of the overall observation of all phenomena in our universe.
- The knowledge of Newton's laws of motion is what you need to describe the forces of any moving object.

**12. For each set find one word mentioned in the text that fits all sentences.**

**A**

a) Lifting a big rock is pretty hard _____.
b) _____and energy are measured in Joules.
c) You can find all the necessary information in this _____of reference.

**B**

a) A meteorite is a space _____which falls on the earth's surface.
b) His whole _____ was trembling with fear when he realized that he wouldn't be able to stop his car.
c) The main _____ of the article was devoted to the Fermi paradox.

**C**

a) His sole _____in life is to explore the properties of dark matter.
b) When a falling _____reaches terminal speed, its speed can't increase anymore.
c) A transitive verb has a direct _____ .

**13. Answer the questions to the text.**

1) What does the first law of motion postulate? Where can we see the action of the law in practice?
2) What does the second law of motion state? How is it expressed algebraically? Can you give examples of its work?
3) What is the third law of motion? How does it work?
4) Where don't Newton's laws of motion work? Why? What theories explain the motion there?

**14. Read the sentences and mark (T) True or (F) false.**

1. There are no perfect demonstrations of the first law of motion, as friction causes a force to act on a moving body.
2. Newton's second law states that for every action there is reaction.
3. Friction causes a force that decelerates the object.
4. The force needed to accelerate an object is proportional to the object's size.
5. Newton's laws still work for the objects moving close to the speed of light.
6. Newton introduced the terms of acceleration and mass into the first law.
7. According to the third law mass is a unit of matter.
8. Acceleration depends on the object's weight.
9. To move with a steady speed the forces must be in balance.
10. The first two laws are related to the motion of two objects.

**15. Fill in the gaps with the new words in the correct form:**

**Part A**

*constant* *pressure* *proportional* *resistance* *inertia*

*velocity* *decelerate* *wheels* *constituent* *exert*

1. Air _____ pushes against objects which are moving through the air.
2. We are confronted with a large number of particles, which together seem to be the fundamental _____ of matter.
3. _____ is measured in pascals (Pa).
4. No force means no acceleration, and hence the body will maintain its _____.
5. The alteration of motion is ever _____ to the motive force impressed.
6. According to Newton, whenever objects A and B interact with each other, they _____ forces upon each other.
7. When you accelerate a car from rest, the road provides an unbalanced force on the spinning _____ to push the car forward.
8. Have you ever experienced _____ in a car while it is braking to a stop?
9. Colliding with the wall, an unbalanced force acts upon the car to abruptly _____ it to stop.
10. As the car maintains a _____ speed, the passengers maintain a _____ speed as well.

**Part B**

*confined* *incline* *take over* *kinetic* *potential*

*propelling* *stationary* *recoil* *hurled* *friction*

1. _____ between moving parts warms up the gears and bearings.
2. If no force is acting on an object, it is either _____ or moving with a constant speed in a straight line.
3. At first he succeeded in _____ the car through the mud then the wheels got stuck in it.
4. When the crew of the shuttle went to bed Mission Control and the shuttle's computers _____ for the night.
5. The _____ energy depends on the mass of the object and on the square of the speed.
6. The land _____ gently towards the shore.
7. Rocket propulsion is essentially the same as the _____ of a gun.
8. Gravitational _____ energy is the stored energy that an object has because of its position above the surface of the Earth.
9. This theory was actually _____ to geometrical optics and didn't deal with the phenomena of physics optics.
10. He _____ a brick through the window.

**16. Use the words given in brackets to form a word that suits in the gaps**.

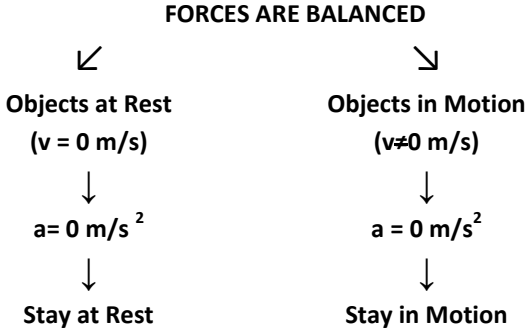
1) The _____ forces always act against the direction of motion (*resist*).
2) Acceleration is _____ of a velocity-time graph (*grade*).
3) It's dangerous to cycle on a _____ icy surface (*friction*).
4) Faraday's law subjected to _____ test, is one of the most exact laws in _____ science (*experiment*, *physics*).
5) All books are____ into two classes: the books of the hour, and the books of the time (*divide*). (J.Ruskin)
6) Accurate _____ of the task was the only aim of the work (*complete*).
7) The second _____ is far more serious (*limit*).
8) Unfortunately, his speculations were _____ (*logic*).
9) Despite all preventive actions the radiation loss was _____ (*avoid*).

10) This problem should be solved in all its _____ (*complex*).

**17. Complete these sentences with information that reflects your personal views.**

I. There are many applications of Newton's first law of motion…
II. The behavior of all objects can be described by saying that objects tend to 'keep on doing what they're doing'…
III. Newton's laws are not applicable on non-inertial frames of reference…

**18. In pairs, discuss the following diagram.**




**19. Watch a video 'Newton's laws of motion' and fill the gaps with the true information.**

1)The gravity pulling the spheres down is … by the force of the tabletop pushing the spheres up in the exact … direction.

2)The balance of forces is what keeps the spheres … on the table.

3)The external force collides with the spheres and changes their … .

4) The natural tendency of an object to remain … or in a … motion in a straight line is called inertia.

5) Acceleration depends upon the … of the object and … of the applied force.

**20. Complete each sentence by matching it with the appropriate ending.**

| | |
|---|---|
| 1 In most real situations there are at least | a) Straight downwards |
| 2 To keep going at a steady speed | b) When he discovered the principle of inertia |
| 3 Acceleration is | c) Continues in its state of rest or uniform motion unless an unbalanced force cats on it |
| 4 When a resultant force acts on an object | d) It has a motion of rotation |
| 5 When something falls | e) Two forces acting on an object along any direction |
| 6 Gravity always acts | f) It causes a change in momentum in the same direction as the forces |
| 7 Power is | g) Its gravitational potential energy is converted into kinetic energy |
| 8 The first law of motion states that a body | h) The work done, or energy transferred, divided by time |
| 9 If a body turns on a fixed axis | i) there must be zero resultant force |
| 10 Galileo made a great advance in the understanding of motion | j) the same direction as the force. |

**21. Check your understanding**

I. While driving down the road, a firefly strikes the windshield of a bus and makes a quite obvious mess in front of the face of the driver. This is the clear case of Newton's third law of motion. The firefly hits the bus and the bus hits the firefly. Which of the two forces is greater: the force on the firefly or the force on the bus?

II. For years, space travel was believed to be impossible because there was nothing that rockets could push off in space in order to provide the propulsion necessary to accelerate. This inability of a rocket to provide propulsion is because…

a) … space is void of air so the rockets have nothing to push off of.
b) … gravity is absent in space.
c) … space is void of air and so there is no air resistance in space.
d) … nonsense! Rockets do accelerate in space and have been able to do so for a long time.

III. Many people are familiar with the fact that a rifle recoils when fired. This recoil is the result of action-reaction force pairs. A gunpowder explosion creates hot gases that expand outward allowing the rifle to push forward on the bullet. Consistent with the Newton's third law of motion, the bullet pushes backwards upon the rifle. The acceleration of the recoiling rifle is…

a) … greater than the acceleration of the bullet.
b) … smaller than the acceleration of the bullet.
c) … the same size as the acceleration of the bullet.

**22. In pairs, role-play conversations in which two scientists discuss the significance of Newton's laws of motion.**

**23. Choose the correct answer A, B, or C from the list below.**

**John Harrison's Clock's**

In the 17th and early 18th centuries sailors' lives were (1) _____ because of their inability to (2)_____ where they were. The British government offered a cash prize of £20,000 to someone who could overcome the technical problems of longitude measurement.

Because of the time differences as you travel from east to west across the globe, longitude can be measured by (3) _____ your local time at sea, say at midday, with the time at some other known place, such as Greenwich in London. Greenwich lies at zero degrees (4) _____ because time was noted relative to the (5) _____ there; we now call it Greenwich Mean Time. This was all well and good, but how could you know the time in Greenwich if you were in the middle of the Atlantic? At the start of the 18th century, this was not easy.

Clock technology at that time was not so advanced and the most (6) _____ timepieces incorporated pendulums that were useless on a (7) _____ ship. John Harrison, a British watchmaker, invented new devices that used rocking weights on (8) _____ instead of a dangling pendulum. But in sea tests even these (9) _____ to impress. One problem with using springs for timing was that their stretchiness changes with (10). _____. For ships sailing from the tropics to the poles this made them impractical. Harrison came up with a novel solution. He incorporated into the clock a bimetallic (11) _____, made from two different metals bonded together. The two metals, such as brass and steel, expand by different amounts as they warm up, causing the strip to (12) _____. Incorporated into the clock mechanism the strip compensated for the temperature changes. Harrison's new clock, called a (13)_____, won the cash prize and solved the longitude problem.

| | | | |
|---|---|---|---|
| 1 | A dangerous | B in peril | C troublesome; |
| 2 | A determine | B locate | C pinpoint; |
| 3 | A comparing | B calculating | C identifying; |
| 4 | A longitude | B latitude | C height; |
| 5 | A observer | B Big Ben | C observatory; |

| | | | |
|---|---|---|---|
| 6 | A reliable | B accurate | C expensive; |
| 7 | A sailing | B rocking | C rolling; |
| 8 | A hooks | B chains | C springs; |
| 9 | A failed | B succeeded | C didn't pass; |
| 10 | A pressure | B humidity | C temperature; |
| 11 | A stripe | B strip | C spring; |
| 12 | A bend | B stretch | C contract; |
| 13 | A grandfather clock | B chronometer | C watch. |

**24. Test yourself.**

1) Can forces be seen? How do we know they're there?
2) What are the units of force? What would you use to measure force?
3) What different things that forces can make objects do?
4) What do balanced forces produce? What do unbalanced forces do?
5) What is air resistance? What's the best shape for avoiding air resistance?
6) Give good and bad points of friction.
7) What is pressure? Give the formula for calculating pressure.
8) Explain how an elephant can walk on dodgy sand but a car would sink.
9) What is the difference between instantaneous speed and average speed?
10) What is the weight of 2kg of sugar?
11) How much does a 100g apple weigh…
    a) on the Earth; b) on the Moon?
12) Why is it difficult to walk on ice?
13) How does a rocket move in outer space where there is nothing to push against to get moving?
14) When you release a partly inflated balloon it flies around as it deflates. Explain why.
15) A book is placed on a table. What are the two interaction pairs of forces?
16) A toy car with mass of 0.5 kg and speed 4m/s collides with a toy truck of mass 2 kg. They both stop.
What is the speed of the truck?
17) Calculate the momentum of a ball of mass 2kg and velocity 5m/s.
18) A force of 50 N acts on a stationary object for 12 seconds. Calculate its gain in momentum.

**25. Translate the following paragraph into Russian**.

A variety of action-reaction force pairs are evident in nature. Consider the propulsion of a fish through the water. A fish uses its fins to push water backwards. But a push on the water will only serve to accelerate the water. Since forces result from mutual interactions, the water must also be pushing the fish forwards, propelling the fish through the water. The size of the force on the water equals the size of the force on the fish; the direction of the force on the water (backwards) is opposite the direction of the force on the fish (forwards). For every action, there is an equal (in size) and opposite (in direction) reaction force. Action-reaction force pairs make it possible for fish to swim.

**26. Translate the paragraph into English.**

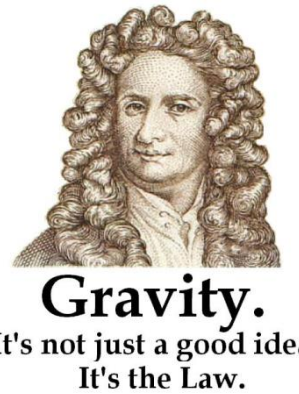
Из трех фундаментальных законов движения Ньютона вытекают следствия, одно из которых – сложение количества движения по правилу параллелограмма. Ускорение тела зависит от величин, характеризующих действие других тел на данное тело, а также величин, определяющих особенности этого тела. Механическое действие на тело со стороны других тел, которое изменяет скорость движения данного тела, называют силой. Она может иметь

разную природу. Изменение скорости движения тела зависит не от природы сил, а от их величины. Поскольку скорость и сила – векторы, то действие нескольких сил складывается по правилу параллелограмма. Свойство тела, от которого зависит приобретаемое им ускорение, есть инерция, измеряемая массой. В классической механике, имеющей дело со скоростями, значительно меньшими скорости света, масса является характеристикой самого тела, не зависящей от того, движется оно или нет. Масса тела в классической механике не зависит и от взаимодействия тела с другими телами. Это свойство массы побудило Ньютона принять массу за меру материи и считать, что величина ее определяет количество материи в теле. Таким образом, масса стала пониматься как количество материи.

## Part II "Newton's law of gravitation"

*'Gravity is a habit that is hard to shake off'*

Terry Pratchet, 1992




1. **In pairs or small groups discuss the questions.**
   1) Why does fruit fall from the trees?
   2) Why doesn't the Moon fall to the Earth?
   3) What is gravity?

Newton's Law of Gravitation says:
'Every object in the universe attracts every other object along a line of the centers of the objects, proportional to each object's mass, and inversely proportional to the square of the distance between the objects.'(1687)

2. **Read and complete the text with the words below.**

ALL FALL DOWN

[1] Isaac Newton made a giant leap when he 1) _____ the motions of cannonballs and fruit falling from trees to the movements of the planets, thus linking heaven and earth. His law of gravitation remains one of the most powerful ideas of physics, explaining much of the physical 2) _____ of our world. Newton argued that all bodies attract each other through the force of gravity and the strength of that force drops off with distance squared.

[2] When Olympic hammer- throwers spin on their heels, it is the 3) _____ on the string that keeps the hammer rotating. Without this pull of the hammer would fly off in a straight line, just as it does on its release. It's just the same with Newton's cannonball- without the centrally directed force 4)_____ the projectile to Earth, it would fly off into space. Thinking further, Newton reasoned that the Moon also hangs in the sky because it is held by the invisible tie of gravity. Without gravity it too would fly off into space.

[3] (A) Newton showed that gravity follows an inverse law- the strength of gravity decreases by 5)_____ of the distance from a body. So if you travel twice some distance from a body its gravity is four times less; the gravity exerted by the Sun would be four times less for a planet in an orbit twice as far from it as the Earth, or a planet three times distant would experience gravity nine times less.

[4] (B) Newton's law predicted that the planets travelled quicker near the Sun as they followed their elliptical paths. A planet feels a stronger gravitational force from the Sun when it travels close to it, which makes it 6) _____. As its speed increases the planet is thrown away from the Sun again, gradually slowing back down. (C) Thus, Newton pulled together all the earlier work into one profound theory.

[5] (D) Newton then proposed that his theory of gravity applied to everything in the universe. Any body exerts a gravitational force in 7) _____ to its mass, and that force falls off as the inverse

square of distance from it. So any two objects attract each other. But because gravity is a 8) _____ force we only really observe this for massive bodies as the Sun, Earth and planets.

[6] If we look closer, though, it is possible to see tiny variations in the local strength of gravity on the surface of the Earth. Because massive mountains and rocks of differing density can raise or reduce the strength of gravity near them, it is possible to use a 9) _____ to map out geographic terrains and to learn about the structure of the Earth's crust. Archaeologists also sometimes use tiny gravity changes to 10)_____ buried settlements. Recently, scientists have used gravity-measuring space satellites to record the amount of ice covering the Earth's 11) _____ and also to detect changes in the Earth's crust following large earthquakes.

[7] Newton's universal law of gravitation has stood for hundreds of years and still today gives a basic description of the motion of bodies. However, science does not stand still, and 20th -century scientists built upon its foundations, notably 12) _____ with his theory of general relativity. Newtonian gravity still works well for most objects we see and for the behavior of planets, comets and asteroids in the solar system that are spread over large distances from the Sun where gravity is relatively weak. Although Newton's law of gravitation was powerful enough to predict the position of the planet 13)_____, discovered in 1846 at the expected location beyond Uranus, it was the orbit of another planet, 14) _____, that required physics beyond that of Newton. Thus general relativity is needed to explain situations where gravity is very strong, such as close to the Sun, stars and black holes.

| | | | |
|---|---|---|---|
| *a. spot* | *e. Einstein* | *i. poles* | *m. Neptune* |
| *b. proportion* | *f. gravity* | *j. behavior* | *n. tying* |
| *c. Mercury* | *g. weak* | *k. square* | |
| *d. Connected* | *h. speed up* | *l. pull* | |

**3. Look at the four lettered spaces in the text (A), (B), (C), (D) that indicate where the following sentence can be added to the passage. Where would this sentence fit best?**

*Newton's inverse square law of gravity explained in one equation the orbits of all the planets as described in the three of Johannes Kepler.*

**4. Read the text again and find the words that mean the same as the following phrases.**

a) not moving;
b) true at all times and in all places;
c) in the form of an ellipse;
d) makes something move towards something;
e) opposite in amount or position to something;
f) any object that is thrown as a weapon;
i) the number obtained when you multiply a number by itself;
j) plan or arrange something in a careful or detailed way.

**5. In pairs, discuss and write the definitions for the following terms from the text. Use a dictionary to help you.**

**6. Identify the purpose.**

**A.** By saying "Newton pulled together all the work into one profound theory' the author means:

1) He combined all laws of motion discovered by him into one theory;

2) He used his discoveries and Kepler's laws to create the Law of gravitation;
3) All his previous laws were combined into one law of gravity.

**B.** The phrase "that required physics beyond that of Newton" means:

1) Newton's laws weren't able to discover Neptune;
2) Application of Newton's laws were not enough to discover Neptune;
3) Astronomers didn't use Newton's laws to discover Neptune.

**C.** The author says that "the Moon also hangs in the sky" and it means;

1) The Moon never changes its constant orbit;
2) The Moon doesn't move relatively to the Sun;
3) The Moon keeps its position in the sky because of gravity.

**7. Fill in the gaps with the new words from the text in the correct form:**

*inversely, profound, rotate, elliptical, attract, reason, distance, map out, basic, satellite.*

**Part A**

1) The charges _____ each other across the dielectric.
2) The physical properties of molecules depend on the forces acting between them and the _____ between them.
3) The drive wheels of a locomotive are moving forward and at the same time _____ .
4) Being unacquainted with mathematical symbols and methods, Faraday always sought to explain his discoveries and to extend his research by purely physical _____ .
5) Kepler described how planets follow _____ orbits and how more distant planets orbit more slowly around the Sun.
6) The magnetic field can be _____ by applying iron fillings to a piece of pasteboard through which a heavy current- carrying conductor is passed.
7) A _____ property of matter is its mass.
8) The device which introduces resistance into a circuit is directly proportional to the applied voltage and _____ proportional to the resistance.
9) Pauli answered one of the most _____ questions in physics.
10) Kepler's laws apply equally to any body in orbit around another, from comets, asteroids and moons in our solar system to planets around other stars and even artificial _____ whizzing around the Earth.

**Part B**

*spread, spot, still, density, universal, pull, release, gravity, motion, experience*

1) After this the rocket if it were originally standing _____, will be moving with a small velocity.
2) Because macroscopic objects have minuscule wavelength, too small to see, we can't _____ them behaving like waves.
3) Time and space distort when approaching the _____ speed of light.
4) A force is a push or a _____ that acts upon an object as a result of its interaction with another object.
5) As a result of these impacts, energy is _____ in the form of heat.
6) The quantity of electricity per unit area is called the surface charge _____ .
7) Under the influence of _____ alone all objects fall with the same acceleration.
8) Some bodies reverse their _____ from time to time and return at regular intervals to the original positions.
9) All large objects in space _____ gravity.
10) Millions of cosmic bodies are _____ all over our universe.

**8. For each set find one word that will fit in all sentences**.

**A**

1) From his _____ on the cliff top, he had a good view of the sea.
2) This put him and his colleagues in a difficult _____ .
3) He held a senior _____ in a large IT company.

**B**

1) The main _____ was a favorite place of rest of local people.
2) The _____ of 7 is 49.
3) The teams were all _____ at half-time.

**C**

1) Write the title of your essay on the top _____.
2) When they arrived at the airport they saw a lot of passengers standing in a _____ at the check-in.
3) Adidas is starting a new _____ of sportswear next month.

**9. Choose the correct answer A, B, or C from the list below.**

Rotating Earth

Pendulums are (1) to the Earth's rotation. The spin of the Earth causes the (2)_____ of its swing to slowly turn. If you imagine a pendulum hanging above the North Pole, it swings in a plane that is fixed (3) _____ to the stars. The Earth rotates (4) _____ it, so watching from a spot on the Earth its swinging motion seems to rotate 360 degrees in a day. There is no such rotation effect if the pendulum is hung above the (5) _____ because the pendulum rotates with the Earth, so its swing plane does not change. From any other (6) _____ the effect lies somewhere in between. So, the fact that the Earth is rotating can be proved by simply (7) _____ a pendulum.

French physicist Leon Foucault famously devised a very public demonstration of this by hanging a huge 70-metre-high pendulum from the ceiling of the Pantheon in Paris. Today, many museums around the world also host giant Foucault pendulums. To work, their first swing needs to be set off very (8) _____ so that the swing plane is (9) _____ and no (10) _____ are introduced. The traditional way to do this is to (11) _____ the bob back with a string and then (12) _____ through the string with the candle to release it gently. To keep the giant pendulums moving for a long time they are often motor assisted to offset slowing due to air resistance.

| | | | |
|---|---|---|---|
| 1) | A relative | B sensitive | C connected; |
| 2) | A plane | B axis | C angle; |
| 3) | A irrespective | B tilted | C relative; |
| 4) | A above | B perpendicular | C beneath; |
| 5) | A equator | B poles | C any place on the surface; |
| 6) | A longitude | B place | C latitude; |
| 7) | A swinging | B watching | C stopping; |
| 8) | A slowly | B smoothly | C abruptly; |
| 9) | A steady | B inclined | C fixed; |
| 10) | A curves | B rotations | C twists; |
| 11) | A press | B tie | C push; |
| 12) | A burn | B stretch | C cut. |

**10. Answer the questions to the text.**

1. Why do all bodies attract each other?
2. How is gravity quantified? Give some examples.
3. How does the Newton's law of gravitation explain the elliptical paths of the planets?
4. What variations in the local strength of gravity can be seen on the surface of the Earth?
5. What discoveries did this law predict?
6. What new theories were built upon its foundations?

**11. Complete these sentences with information that reflects your personal views.**

1) Newton's law of gravitation also explains…
2) Gravity never goes to zero…
3) Stars feel the gravity from…
4) There is no way to get rid of gravity..

**12. Watch a video about gravitation and finish the sentences.**

1) Gravity is the force to hold us…
2) The gravitation force between two objects also depend on how …
3) You and the Earth both have mass therefore you …
4) When you jump you push away from the Earth that's because…
5) Astronauts on the Moon experience ….
6) Gravity even holds…

**13. Read the sentences and circle (T) True or (F) False.**

1) Newton stated that his gravity law worked for any two objects with mass.
2) Gravity depends only on the masses of the two attracting objects.
3) Gravity can be either attractive or repulsive.
4) Newton's law of gravity also explained Kepler's 1st and 2$^{nd}$ laws.
5) Gravity has direct relation with distance.
6) Gravity never goes to zero.
7) Gravity depends on the chemical composition or density.
8) On the surface of a planet, gravity makes all things accelerate towards the ground, all with the same acceleration.
9) An object has the same weight whether it's on Earth or on the Moon – but its mass will be different.
10) Weight is caused by the pull of gravity.

**14. Use the words given in brackets to form a word that fits in the gap.**

1) Whether this could be achieved with a _____ mechanization was to be determined (**three).**
2) These _____ represent a direct demonstration of the applicability of this method (**find).**
3) This process is presently seen as ____ from the point of view of less developed countries (problem).

4) A _____ decrease in yield was observed (**six).**
5) Rather than solving one problem the technique involves the _____ solution of a series of sub-problems (**repeat).**
6) The lattice _____ may result from mechanical polishing (**distort)**.
7) Zero seems like an _____, like nothing, how then can we legitimately refer to zero as if it were something, a genuine number? (**empty)**
8) Intuitive conclusions based on immediate observation are not always to be trusted, for they often _____ (**lead).**
9) In some phenomena the _____ appears only after several super-imposed _____ have been analyzed out (**period, period).**
10) The results were affected by the presence of _____ **(pure).**

**15. In pairs or small groups, discuss the following questions.**

1) What basic fundamental assumption did Newton make about the laws of nature on the Earth and in space?
2) Why is gravity often the most important force in astronomical interactions?
3) What things does gravity depend on?
4) How does gravity vary with distance between objects and with respect to what do you measure the distances?
5) What would happen to the Earth's orbit if the Sun suddenly turned into a black hole (of the same mass)?
6) How would antimatter respond to gravity?
7) What important laws of planet motion can be derived from Newton's law of gravity?

**16. In pairs, role-play conversations in which you discuss the discoveries related to the Newton's law of gravity.**
**17. Now write a list of specific questions to a tester on the Newton's Law of Gravity.**
**18. Translate the paragraph into Russian**.

The Discovery of Neptune

The planet Neptune was discovered thanks to the Newton's law of gravitation. In the early 19$^{th}$ century, astronomers noticed that Uranus did not follow a simple orbit but acted as though another body was disturbing it. Various predictions were made based on Newton's law and in 1846 the new planet, named Neptune after sea god, was discovered close to the expected position.

British and French astronomers disagreed over who had made the discovery, which is credited to both John Couch Adams and Urbian Le Verrier. Neptune has a mass 17 times that of the Earth and is a gas giant with a thick atmosphere of hydrogen, helium, ammonia and methane smothering a solid core. The blue color of Neptune's clouds is due to methane. Its winds are the strongest in the solar system, reaching as much as 2500 kilometers per hour.

**19. Translate the paragraph into English.**

Тяготение действует на огромных расстояниях во Вселенной. Но Ньютон утверждал, что взаимно притягиваются все предметы. А правда ли, что любые два предмета притягивают друг друга? Только представьте, что Земля притягивает вас, сидящих на стуле. Но задумывались ли о том, что карандаш и ручка, лежащие на столе, притягивают друг друга. В этом случае в формулу закона притяжения подставляем массу ручки, массу карандаша, делим на квадрат расстояния между ними, с учетом гравитационной постоянной, получаем силу их взаимного притяжения. Но, она выйдет настолько маленькой, что мы не ощущаем ее наличие. Другое дело, когда речь идет о

земле и о стуле, или Солнце и Земле. Массы значительные, а значит действие силы мы уже можем оценить.

**20. Test yourself.**

1) How do the acceleration and force due to gravity depend on the radius and mass of a planet?
2) How does the mass of a falling object affect the rate at which it falls in a gravitational field?
3) Why do inner planets move faster than the outer planets?
4) Does gravity go forever?
5) Why do some scientists think that the term 'weightlessness' is not really true?
6) Can we figure out how hard the Earth is pulling us?
7) How does the Newton's Second Law of Motion relate to gravity?
8) What happens as the rocket burns its fuel?
9) Are astronauts really weightless in orbit?
10) How can you experience free fall without leaving the Earth?
11) Would you weigh more or less on Mercury than you do on the Earth? How about Jupiter?
12) How much would you weigh on the Moon?
13) If the satellite weighs 150 000 kg on the surface of the Earth, how much does weigh in an orbit of 600 km away the Earth's surface?

HOW TO READ MATHEMATICAL EXPRESSIONS

**21. Study the material.**

Addition

| | |
|---|---|
| $1 + 3 = 4$ | One plus three equals four; one and three makes four; the sum of one and three is four; one and three total four; one and three amount to four. |

Subtraction

| | |
|---|---|
| $10 - 5 = 5$ | Ten minus five equals five; five from ten leaves five; taking five from ten gives five; subtraction five from ten gives five |

Multiplication

| | |
|---|---|
| $4 \cdot 2 = 8$ | Four times two equals eight; four multiplied by two equals eight; the product of four and two is eight; twice four is eight |

Division

| | |
|---|---|
| $9 \div 3 = 3$ | Nine divided by three equals three; |
| $520 \div 37 = 14\frac{5}{37}$ | Divide five hundred and twenty by 37 gives the quotient 14 and five thirty- seventh |

Decimal numbers

| | |
|---|---|
| $0.145$ | Zero point one four five |
| $102.335$ | One hundred two point three three five |
| $3.\dot{3} = 3.333\ldots$ | Three point three recurring |
| $1.0\dot{3}6\dot{3}$ | One point zero three six three recurring |

When decimal numbers are repeating, they are called *recurring, circulating* or *repeating*.

Fractions

| | |
|---|---|
| $\frac{1}{2}$ | One half |
| $\frac{1}{4}$ | One fourth/ a quarter |
| $\frac{3}{4}$ | Three quarters/ three fourths |
| $3\frac{1}{2}$ | Three and half |
| $\frac{120}{511}$ | One hundred twenty over five hundred eleven/<br>One hundred twenty divided by five hundred eleven/<br>One twenty divided by five eleven |

Powers and roots

| | |
|---|---|
| $a^2$ | *a* squared |
| $b^3$ | *b* cubed |
| $a^4$ | *a* to the fourth power |
| $a^{-5}$ | ***a*** to the negative fifth |
| $a^{n-b}$ | ***a*** to the ***n*** minus ***b*** |
| $\frac{a^6}{b^3}$ | ***a*** to the sixth divided by ***b*** cubed |
| $\sqrt{6}$ | The square root of six |
| $\sqrt[n]{x}$ | The ***n*** th root of ***x*** |

Proportion

| | |
|---|---|
| $3 : 9 = 1 : 3$ | Three is to nine as one to three;<br>The ratio of three to nine equals that of one to three;<br>The two ratios between three to nine and one two three are equal |

Equations with parentheses and brackets

| | |
|---|---|
| $\left(1-\frac{4}{5}\right)\cdot 2\frac{1}{3}$ | One minus four fifths, and all multiplied by 2 and one third |
| $x = c\left\{a\left[\frac{z}{Z}\left(d-\frac{1}{y-Y^2}\right)\right]\right\}$ | ***x*** equals ***c*** (open) curly bracket ***a*** (open) bracket small<br>*z* over large *Z* (open) parenthesis d minus one over the quantity of small *y* minus large *Y* squared, (close)<br>parenthesis (close) bracket and curly bracket |
| $x = ab^{n-1} + a^2b^{n-2} + \cdots + a$ | *x* equals a times *b* to the minus one (power) plus a squared times *b* to the n minus two (power) down to<br>*a* to the *n* *th* (power) |

**22. Give some examples of equations and formulas for your group mates to read .**

MINI GRAMMAR

ARTICLES

**23. Study the explanations and examples.**

[1] We can use *the* when we make generalizations about classes of things using **singular countable nouns.** Compare the use of **the** and **a/an** in these sentences;

- *The **computer** has revolutionized publishing. (this refers to computers in general) but not A **computer** has revolutionized publishing.( Computers in general have done this, not an individual computer)*
- *The **computer** is an important research tool. And*
- *A **computer** is an important research tool. (This statement is true of both the general class and the individual item)*

[2] As an alternative to **the + singular countable** noun we can use a plural countable noun to talk about a class of things:

- ***Computers** are an important research tool.*

[3] Note that if **the** is used with plural and uncountable nouns we refer to a specific thing or group:

- ***The computers** have arrived. Where shall I put them?*
- ***The music** was wonderful. I could have listened to **the orchestra** all night.*

[4] When we define something or say what is typical of a particular class of people or things, we generally use **a/an** rather than **the**:

- *A corkscrew is a gadget for getting corks out of bottles.*

**24. Choose the correct or more likely answer. In some sentences both answers are possible.**

1) We get some strange requests in our service station. We had the customer/ a customer the other day who wanted us to decorate his car with road signs.
2) It often seems that the individual/ an individual can have little impact on government policy.
3) The invention of a car/ the car is normally attributed to the German engineer Gottlieb Daimler.
4) The television/ a television has changed the way we think more than any other modern invention.
5) The campaign against smoking in public places argues that its harmful effects are not confined to the smoker/ a smoker.

# Unit 3: MATTER IN MOTION

## Part III **"CONSERVATION OF ENERGY"**

*"It is a strange fact that we can calculate some number and when we finish watching nature go through her tricks and calculate the number again, it is the same."*

Richard Feynman, 1961

1. **In pairs or small groups discuss the questions**.
   1) What is energy?
   2) How many forms of energy exist? What types of energy do you know?
   3) What types of energy are the most frequent?
2. **Match the terms with their definitions**.

| | |
|---|---|
| 1conversion | a) is the product of an object's mass and its velocity |
| 2 conservation | b) a process of changing something from one form, use or system to another |
| 3 angular momentum | c) the act of prevention something from being lost, wasted, damaged or destroyed |
| 4 linear momentum | d) is the product of an object's mass, its speed, and its distance from the axis of rotation |

3. **Read the text and fill in the gaps with missing sentences. One sentence is extra.**
   a) Conservation of angular momentum is used to effect in performances by spinning ice skaters.
   b) This energy is released in a nuclear explosion or in the fusion reactors that power our Sun.
   c) More cannot be created and it can never be destroyed.
   d) A compressed spring can store within it elastic energy that can be released on demand.
   e) One is gravitational potential energy, which may raise a body above the Earth in opposition to gravity.
   f) Two other concepts are closely related – the conservation of linear momentum and the conservation of angular momentum.

[1] Energy is an animating force that makes things move or change. It comes in many guises and may manifest itself as a change in height or speed, travelling electromagnetic waves or the **(a) vibrations** of atoms that cause heat. Although energy can metamorphose between these types, the **(b) overall** amount of energy is always conserved. (1) _____

[2] Coming in so different guises, energy is difficult to define. Even now, physicists do not know intrinsically what it is, even though they are expert at describing what it does and how to **(c) handle** it. Energy is a property of matter and space, a sort of **(d) fuel** or encapsulated drive with the potential to create, to move or to change. Philosophers of nature going back to the Greeks had a

vague notion of energy as a force or essence that gives life to objects, and this idea has stuck with us through the ages.

[3] It was Galileo who first spotted that energy might be transformed from one type to another. Watching a pendulum swinging back and forth, he saw that the bob exchanges height for forward motion, and vice versa and repeats the cycle. The pendulum bob has no sideways velocity when it is at either peak of its **(e) swing**, and moves quickly as it passes through the lowest point.

[4] Galileo reasoned that there are two forms of energy being swapped by the swinging bob. (2)_____

[5] Gravitational energy needs to be added to lift a mass higher, and is released when it falls. If you have ever cycled up a steep hill you will know it takes a lot of energy to combat gravity. The other type of energy in the bob is kinetic energy – the energy of motion that accompanies speed. So the pendulum converts gravitational potential energy into kinetic energy and **(f) vice versa**.

[6] Energy manifests as many different types that can be held temporarily in different ways. (3)_____

[7] Heat energy increases the vibrations of atoms and molecules in the hot material. So a metal pan on a cooker heats up because the atoms within it are being made to **(g) wobble** faster by the (h) input of energy. Energy can also be transmitted as electric and magnetic waves, such as light or radio waves, and **(j) stored** chemical energy may be released by chemical reactions, as happens in our own digestive systems.

[8] Einstein revealed that mass itself has an associated energy that can be released if the matter is destroyed. So, mass and energy are equivalent. This is his famous $E= mc^2$ equation - the energy ($E$) released by the **(k) destruction** of a mass ($m$) is $m$ times the speed of light ($c$) squared. Energy conservation as a rule of physics is much more than reducing our use of household energy; it states that the total amount of energy is unchanged even though it may switch between different types.

[9] It was noticed that kinetic energy alone was not conserved. Balls or flywheels slowed down and didn't move forever. But fast motions did often cause machines to heat up by friction, such as when boring metal cannon tubes, so experimenters **(l) deduced** that heat was one destination for released energy. Gradually, on accounting for all the different types of energy in built machines, the scientists began to show that the energy is transferred from one type to another and is not destroyed or created.

[10] The idea of conservation in physics is not limited to energy. (4)_____

[11] Linear momentum is defined as the product of mass and velocity, and describes the difficulty of slowing a moving body. A heavy object moving quickly has high momentum and is difficult to **(m) deflect** or to stop. So a truck moving at 60 km an hour has more momentum than a car moving at the same speed, and would do even more damage if it hit you. Momentum has not just a size but, because of the velocity, it also acts in a specific direction. Objects that collide exchange momentum such that overall it is conserved, both in amount and direction. If you have ever played billiards or pool you have used this law. As two balls collide, they transfer motion from one to the other so as to conserve momentum. So if you hit a still ball with a moving one, the final paths of both balls will be a combination of the velocity and direction of the initial moving ball. The speed and direction of both can be worked out assuming that momentum is conserved in all directions.

[12] Angular momentum conservation is similar. Angular momentum, for an object spinning about a point, is defined as the product of the object's linear momentum and the distance it is away from the rotation point. (5)_____
When their arms and legs are stretched out they **(n) whirl** slowly, but just pulling their limbs in to their body they can spin faster. This is because the smaller dimensions require an increased rotation speed to **(o)compensate**.

[13] Conservation of energy and momentum are still basic tenets of modern physics. They are concepts that have found a home even in contemporary fields such as general relativity and quantum mechanics.

**4. Read the text again and find the words that mean the same as the following phrases**.

1) Deal with a situation, area of work or something else;
2) Formed an opinion about something based on the information that is available;
3) Kept somewhere to use later;
4) Change direction or make something change direction;
5) The act of putting something in;
6) In total;
7) A continuous shaking movement;
8) Move from side to side in an unsteady way;
9) Any material that produces heat or power;
10) The act of destroying something;
11) Movement from side to side while hanging from a fixed point;
12) Provide something good to balance or reduce the bad effects of damage;
13) Move, or make something or somebody move, around quickly in a circle;
14) Used to say that the opposite of what is also true;

**5. In pairs, discuss and write definitions for the following terms from the text.**
**Concept, to swap, a bob, to reveal, contemporary, to manifest, a property, equivalent, a spring, to encapsulate**.

**6. Choose the phrase which could replace parts of these phrases.**

**1) It comes in many guises**
a) Energy can have some different types at the same time;
b) It has a lot of properties;
c) It can exist in different types;

2) **Greeks had a vague notion of energy**
a) Greeks didn't have a clear idea about nature of energy;
b) Greeks couldn't explain anything about energy;
c) Greeks were not interested in investigation of energy;

3) **Energy is difficult to define**
a) It's not easy to work out the amount of energy;
b) Scientists still can't explain exactly the nature of energy;
c) It is hard to identify all the properties of energy;

4) **There are two forms of energy being swapped by the swinging bob**
a) Being exchanged;
b) Being transferred one into another;
c) Being replaced;

5) **… energy, which may raise a body above the Earth in opposition to gravity**
a) Overcoming gravity;

b) Destroying gravity;
c) Together with gravity.

**7. Fill in the gaps with the new words in the correct form:**

**Part A**

*Deflect, concept, deduce, overall, reflect, dimension, swirl, pendulum, deflect, vice versa, encapsulate.*

1) Because colour applies only to quarks, not to real particles like protons, the _____ colour of a real particle must be white.
2) Stellar-mass black holes can also be identified by detecting the X-rays from gas_____ around them.
3) Higgs boson's existence was_____ for the purpose of breaking symmetry in electroweak interactions.
4) In 1964 John Bell_____ the difference between quantum and hidden- variable theories in equations.
5) They fired two beams of light at right angles to one another,_____ them back off identical mirrors displaced by exactly the same distance.
6) Every boson has a corresponding fermion or 'superpartner' whose spin differs by ½ a unit, and …
7) Einstein treated the three_____ of space and one of time as aspects of 'space-time'.
8) The_____ of nuclear electrons quickly turned out to be false.
9) Very fine slits spread out the light more widely; and the red is_____ more than blue light.
10) If we pull a mass aside and release_____ , it swings back and forth.

**Part B**

*Compensate, manifest, swap, define, conserve, momentum, spring, contemporary, store, handle.*

1) Elastic energy is the formula for a_____ when it is stretched.
2) … energy in a substance is called potential energy.
3) The_____ of an object is a product of its mass and its velocity.
4) Cosmology suggests space can hold a negative pressure that_____ itself as dark energy, accelerating the expansion of the universe.
5) In the printout the numbers were rounded up to three decimal places, but the computer's memory was_____ numbers with six decimal places.
6) In the case of the refrigerator, cooling the orange juice decreases its entropy, but this is_____ for by the hot air that the appliance produces.
7) Newton's fiercest battles about his theory of color were with his equally famous_____ , Robert Hooke.
8) Energy may_____ from one type to another.
9) The longer period of time, the more precisely energy can be_____
10) Momentum has a direction as well as a size, and both aspects are_____ together.

**8. Choose a sentence which expresses the main idea of the text.**

1) The Law of conservation has become the foundations of modern physics.
2) Energy can change its type but not its amount, so it can't be destroyed.

3) The conservation of energy is connected with the conservation of linear momentum and the conservation of angular momentum.

**9. For each set find one word mentioned in the text that will fit all sentences**.

**A**

1) The car hit a truck coming in the opposite_____
2) All the work in the laboratory was produced by the students under the_____ of their supervisor.
3) He again won the Oscar for_____ of his new film.

**B**

1) The_____ is that you should repeat the experiment but other substances.
2) The task of you lab work is to measure the freezing_____ of different liquids.
3) The numerous experiments described in his article were a strong_____ of his research.

**C**

1) You can_____ thousands of pieces of information in computer's memory.
2) Zara is a famous chain_____ in the world.
3) Researching needs a vast_____ of knowledge.

**10. Use the words in brackets to form a word that fits in the gaps.**

1) Dutch physicist Huygens devised a practical way for predicting the_____ of waves (progress).
2) Huygens was the first to demonstrate that the planet was girdled by a_____ (flat) disk rather than flanked by extra moons or a changing_____ (equator) bulge.
3) His principle is only a useful tool for predicting the_____ (evolve) of waves rather than a fully_____ (explain) of the law.
4) Materials can be designed to possess specific refractive_____ , which may be useful (index).
5) About one in ten stars have planets, and this has_____ speculation that some may even harbor forms of life (fuel).
6) The first_____ planets were detected around a pulsar in 1992 and around a normal star in 1995 (solar).
7) He claimed to have seen the Doppler effect recorded in the colours of light from_____ stars, but this was in his day (pair).
8) When lightning strikes, the electric_____ flows very quickly through the ionized air to the ground (charge).
9) Transformers control the_____ of energy across the electric grid (transmit).
10) It is interesting to note the_____ between the megajoule energies we consume as food and the joule-sized energies we expend in physical activities (proportion).

SPEAKING

**11. Here are some examples of types of energy that can be measured using joules. Match the types of energy with the examples.**

| Type of energy | Examples |
|---|---|
| 1) Chemical energy released by burning | a) MJ are required to melt 1 kg of tin. |
| 2) Energy required to break an object | b) 1 kg of uranium oxide fuel consumed by reactor releases $2\times10_{12}$J of stored nuclear energy |
| 3) Energy required to melt a solid substance | c) Lifting 1.0 kg through a height of 1.0 m requires 9.8 J |
| 4) Chemical energy released by digesting food | d) When a person suffers a spiral fracture of the thighbone (a common type in skiing accidents), about 2J of energy go into breaking the bone |
| 5) Raising a mass against the force of gravity | e) A bowl of Cheerios with milk provides us with about 800 kJ of usable energy |
| 6) Nuclear energy released in fission | f) About 50 MJ are released by burning 1 kg of gasoline |

**12. Answer the questions.**

1) Who was the first scientist who supposed that energy could be transformed from one type to another? What observations made him think so?
2) What conclusions did he come to watching a swinging pendulum?
3) Will you give some examples of different types of energy?
4) What was Einstein's contribution to understanding energy?
5) What does the law of Conservation of Energy state?
6) What are the two other concepts closely related to energy?
7) What is the conservation of linear momentum? Give some examples to illustrate its action.
8) What is the conservation of angular momentum? Give some examples to reveal its action.

**13. Read the sentences and mark T (true) or F (false).**

1) The Conservation Law is a fundamental law of mechanics which is particularly true for isolated systems.
2) Energy is measured with the same units as work, Joules.
3) The sum of kinetic energy of the particles before collision is less than the kinetic energy of the particles after collision.
4) Potential energy does not depend on velocities.
5) The kinetic energy is quadratic form with regard to velocities.
6) Conservation of energy for finite systems is value in all modern physical theories, such as special and general relativity and quantum theory.
7) Conservation of energy is implied by the empirical fact that the laws of physics sometimes change with time itself.
8) The human is a non- conservative system.
9) The Law of conservation of energy includes the possibility of perpetual- motion machines of the first kind.
10) In ancient Italy, Galileo Galilei was the first to realize that energy seemed to be conserved, although he had no means of proving it.

**14. In pairs prepare a dialogue between an examiner and a student who is examined on the Law of Conservation of energy.**

**15. Discussion questions.**

1) Suppose that, like Einstein, you were trying out different equations for kinetic energy to see if they agreed with the experimental data. Based on the positive and negative signs of velocity, why would you suspect that a proportionality to $mv$ would less likely than $mv^2$?
2) If all the air molecules in the room settled down in a thin film on the floor, would that violate conservation of momentum as well as conservation of energy?
3) A helicopter has, in addition to the huge fan blades on top, a smaller propeller mounted on the tail that rotates in a vertical plane. Why?
4) If you throw a feather straight up in the air. When it comes back down to the height from which you released it, you will find that it is going slower. How do you reconcile this with conservation of energy?
5) Hydroelectric power (water flowing over a dam to spin turbines) appears to be completely free. Does this violate conservation of energy? If not, then what is the ultimate force of the electrical energy produced by a hydroelectric plant?
6) Heat is a form of energy and what about temperature?
7) Many types of energy are just variations of them. Do you agree?
8) a) You release a magnet on a tabletop near a big piece of the iron and the magnet leaps across the table to the iron. Does the magnetic potential energy increase or decrease? Explain.

   b) Suppose instead that you have two repelling magnets. You give them an initial push towards each other, so they decelerate while approaching each other. Does the magnetic potential energy increase or decrease? Explain.

9) Energy is consumed in melting and evaporation. Explain in terms of conservation of energy why sweating cools your body, (even though the sweat is at the same temperature as your body).

LISTENING

**16. Listen or watch the video" conservation of energy". Read the sentences and make the right choice. Sometimes more than one option is possible.**

1) The unit was named a Joule after
   a) Joules Hooke;
   b) Joules James;
   c) James Prescott Joules;
2) He came up with the really innovative way to look at
   a) measuring energy;
   b) energy transfer;
   c) types of energy;
3) When an object is at a height it has
   a) magnetic potential energy;
   b) potential energy of stretching;
   c) gravitational potential energy;
4) The speaker compares conservation of energy with a teeter- totter which means
   a) a see-saw;
   b) a pendulum;
   c) a spring;
5) The amount of energy before the interaction of two objects and after is

a) exactly the same;
b) almost the same;
c) different;

6) The energy could be transferred through
   a) work;
   b) collision;
   c) the magnetic field;
7) The energy that drives a car is
   a) electrical energy;
   b) chemical energy:
   c) electromagnetic energy;
8) Through the combustion the energy is transferred into
   a) mechanical energy;
   b) heat;
   c) light;
   d) gravitational energy ;
   e) chemical energy;
9) When you put your hand on an engine you'll notice that it
   a) stays cool;
   b) vibrates;
   c) is hot.

**17. In pairs or small groups, choose any topic from the list below and prepare an oral report.**

1) Hubble's Law and conservation of energy.
2) Discrepancies in the conservation of energy.
3) Dark energy and conservation of energy.
4) Perpetual motion machines.

**18. Momentum and kinetic energy are both measures of the quantity of motion but there are some differences. Say which of them:**

a) is always positive, and cannot cancel out;
b) is always conserved in a closed system;
c) is a vector;
d) is a scalar;
e) cancels with momentum in the opposite direction;
f) is doubled if the velocity is doubled;
g) is not changed by a force perpendicular to the motion which changes only the direction of the velocity vector;
h) can be traded for forms of energy that do not involve motion;
i) is changed by any force, since a change in either the magnitude or direction of the velocity vector will result in a change in the momentum vector;
j) is quadrupled if the velocity is doubled.

**19. Answer the questions.**

1. Is the accelerated expansion of the universe consistent with conservation of energy?
2. Does Big Bang violate the conservation of energy?
3. Why can't energy be created or destroyed?

4. When they say that the universe cooled after Big Bang, where did the heat go?
5. Is energy absolutely conserved in our universe?
6. What would happen if Law of Conservation of energy was violated? Which theories would lose their foundations? What kind of effect would we have in our understanding of universe?
7. Does the Law of Conservation of energy act on atoms?
8. What does a scientist have to do to establish the existence of a new form of energy?
9. Can the kinetic energy of an object be negative?
10. A ball thrown straight up will have the same speed on impact with the ground as a ball thrown straight down at the same speed . How can this be explained using potential energy?

**20. Translate the paragraph into Russian.**

The idea of energy as the cause of transformations was familiar to the ancient Greeks – *energia* means activity in Greek. We know that its magnitude scales with the force we apply and the distance by which an object subjected to it shifts. But energy is still a slippery concept for scientists. It was in investigating the nature of energy that the ideas of quantum physics originated. When we push a supermarket trolley, it rolls along because we are giving it energy. The trolley is being powered by the chemicals combusted in our bodies, transmitted by the force of our muscles. When we throw a ball we also convert chemical energy into motion. The Sun's heat comes from nuclear fusion, where atomic nuclei are crushed together, and give out energy in process.

**21. Translate the paragraph into English.**

В реальных процессах, где действуют силы трения, наблюдается отклонение от закона сохранения механической энергии. Например, при падении тела на Землю сначала кинетическая энергия возрастает, поскольку увеличивается скорость. Возрастает и сила сопротивления, которая увеличивается с возрастанием скорости. Со временем она будет компенсировать силу тяжести, и в дальнейшем при уменьшении потенциальной энергии относительно Земли кинетическая энергия не возрастает. Это явление выходит за рамки механики, поскольку работа сил сопротивления приводит к изменению температуры тела. Нагревание тел при действии трения легко обнаружить, потерев ладони друг о друга. Таким образом, в механике закон сохранения энергии имеет довольно жесткие границы.

MINI GRAMMAR

COMMAS AND OTHER PUNCTUATION

**COMMAS**

- To separate items in a list:
  *e.g. Einstein, Schrodinger and others had difficulty dropping their firm beliefs in an external, deterministic and verifiable universe.*
- To separate some final elements such as question tags and participle clauses:
  *e.g. Cycling at night, you may have used a dynamo to power your bicycle lights.*
  *You can prove anything with statistics, can't you?*

- Around inserted phrases and clauses:
  *e.g. The body hits the airbag, which is compressed, increasing the distance the body moves and the time it takes to stop.*
  *The universe, as we know, looks roughly the same in all directions.*

- To separate off an introductory word, phrase or clause:
  *e.g. Instead, Hoile preferred to believe in a more sustainable vision of cosmos.*
  *In such a situation, the momentum will ultimately be halted by means of the rope, thus preventing a disastrous fall to the ground.*
  *If the collision takes place over a longer time, then the stopping force will be less.*
  *When a resultant force acts on an object, it causes a change in momentum in the same direction as the force.*
  *Following the big bang explosion, the fabric is also continually expanding.*

- In direct speech:
  *e.g. Michael Faraday said:' Nothing is too wonderful to be true if it be consistent with the laws of nature.'*
- Optional before **and, or, but,:**
  *e.g. The incoming electron, or other particle, absorbs a photon to produce a second more energetic electron.*
  *The W boson is not seen in the products of the interaction, but is involved in the intermediate stage*.

Note: the use of the comma before and in a list is much more common in America English than in British English.

**OTHER PUNCTUATION**

**COLON (:)**

- to introduce a list:

*e.g. Young children are natural scientists: they ask questions, pick up sticks and bugs outside, and are curious about the world around them.*

- before a phrase that gives more information or an example:

*e.g. There are different forces for you to know: gravity always acting straight downwards; reactionforce acting straight upwards ;push or pull speeding something up; friction slowing the thingdown and others.*

- to introduce a quotation.

*e.g. As Albert Einstein said: "As far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality."*

**SEMI-COLON (;)**

- to separate two main clauses that are closely linked in meaning, so that a full stop would be too strong break between them:

*e.g. When the Moon passes into the Earth's shadow it is dark; when stars burn out they leave husks too faint to see; even a planet as big as Jupiter would be invisible if it was set free to wander far from the Sun.*

**DASH (--)**

- in informal writing, to separate a part of a sentence which adds extra information:

*e.g. By solving the problem of beta decay, Pauli and Fermi opened a new world of electro-like substitutes-- called leptons -- as well as predicting the existence of neutrino.*

**22. Read these sentences and work out the rules for punctuation.**

1) Particles of opposite charge attract one another; those with like charges repel.
2) Neutrons, as the name suggests, have no charge and so are 'neutral'.
3) Electricity may remain static, as a fixed distribution of charges, or flow, as an electrical current.
4) If the object is moving, it continues to move at the same speed and in the same direction.
5) Physics is the science studying various phenomena in nature: mechanical motion, heat, sound, electricity, magnetism and light.
6) Physics is divided into a lot of different fields – mechanics, sound, heat, electricity and magnetism, light, molecular, atomic and nuclear physics.
7) If we exert a certain push with our arms on an object that is light, it moves easily; if we push just as hard on another object that is much heavier, it moves much less rapidly.

**23. Punctuate these sentences.**

1) All wave crests have the same phase and all troughs are half a circle away from them. If you imagine an ocean wave the distance between two wave peaks known as its wavelength is maybe 100 meters. Its frequencies or the number of wavelengths that pass some point in one second might be one wavelength of 100 meters in 60 seconds or 1 cycle per minute.
2) Mechanical energy potential and kinetic is measured in the same units as work.
3) The rapid progress of atomic power engineering can be explained by its advantages over conventional types energy production atomic power stations do not pollute the atmosphere atomic energy is economical.
4) The momentum of an object is a product of two parts its mass and its velocity.
5) First we'll start with the Newtonian approximation that mass is constant the same all the time and that further when we put two objects together their masses add.
6) In the case of gravitation Newton gave us the complete law of the force. In the case of very complicated forces between the atoms he was not aware of the right laws for the forces however he discovered one rule one general property of forces which is expressed in the Third Law and that is the total knowledge that Newton had about nature of forces the law of gravitation and this principle but no other details.

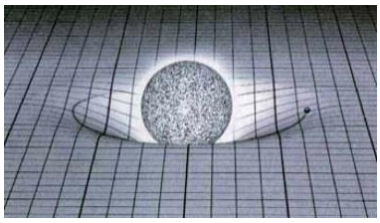
**ARTICLES**

**24. Fill in the gaps with the (- ), (a/an), or (the) articles.**

1) (…)Energy has (…) large number of (…) different forms, and there is (…) formula for each one.
2) We can illustrate (…) existence of (…) in other forms by (…) following example.
3) If we pull down on (…) spring, we must do some work, for when we have it down, we can lift (…) weight with it.
4) Elastic energy is (…) formula for (…) spring when it is stretched.
5) Associated with (…) relativity theory, there is (…) modification of (…) laws of (…) kinetic energy, so that (…) kinetic energy is combined with another thing called (…) mass energy.
6) (…) object has energy from its sheer existence. If we have (…) positron and (…) electron, standing still doing nothing and they come together and disappear, (…) radiant energy will be liberated, in (…) definite amount, and (…) amount can be calculated. All we need to know is (…) mass of (…) object.
7) (…) law of (…) conservation of (…) energy was discovered in (…) middle of (…) $19^{th}$ century.
8) Special credit in (…) discovery of this law belongs to (…) German scientists Robert Meyer and (…) British scientist James Joule.

9) (…) great Russian scientist Mikhail Lomonosov discovered another law – (…) law of (…) conservation of mass – (…) hundred years before (…) discovery of (…) law of (…) conservation of energy.
10) For many centuries (…) energy of (…) wind or running water has been used to set in motion (…) machines, such as (…) mills.

## Part IV "General Relativity"



*"Time and space and gravitation have no separate existence from matter"*

Albert Einstien, 1915

**1. In pairs, or small groups, discuss the questions.**

1) Why is Albert Einstein considered to be a scientist of genius?
2) What Einstein's theories did you study?
3) What do you know about application of his discoveries?

**2. Match the terms with their definitions.**

| | |
|---|---|
| 1) Gravity | a) a measurement in space; |
| 2) Gravitational lensing | b) the universe considered as a continuum with four measurements inside which any event or physical object is located; |
| 3) Worm hole | c) a phenomenon which multiplies images of the same distant astronomical object visible in the sky; |
| 4) Black hole | d )a possible connection between regions of space-time that are far apart; |
| 5) Dimension | e) an area in space that nothing, even light, can escape from, because of gravity; |
| 6) Space-time | f) the force that attracts objects towards each other, and that on the Earth pulls them towards the centre of the planet, so that things fall to the ground when they are dropped. |

**3. Read the text and fill in the missing sentences. One sentence is extra.**

1) Another aspect of relativity is that waves can be set up in the space-time sheet.
2) On 29 May 1919 the world's astronomers gathered to test Einstein's predictions by observing a total eclipse of the Sun.
3) They are so deep and steep that anything that comes close enough can fall in, even light.
4) Over the next few years Einstein explored the consequences.
5) When moving and accelerating, it is this space-time metric that distorts to maintain the fixed speed of light.
6) If you then threw in a smaller ball, say as an asteroid, it would roll down the slope towards the Earth.

**GENERAL RELATIVITY**

[1] Incorporating gravity into his theory of special relativity, Einstein's theory of general relativity revolutionized our view of space and time. Going beyond Newton's laws, it opened up a universe of black holes, worm holes and gravitational lenses.

[2] Imagine a person jumping off a tall building, or parachuting from a plane, being accelerated towards the ground by gravity. Albert Einstein realized that in this state of free fall they did not experience gravity. In other words, they were weightless. Trainee astronauts today recreate the zero gravity conditions of space in just this way, by flying a passenger jet in a path that mimics a roller coaster. When the plane flies upwards the passengers are glued to their seats as they experience even stronger forces of gravity. But when the plane tips forwards and **(1) plummets** downwards, they are released from gravity's pull and can **(2) float** in the body of the aircraft.

[3] Einstein recognized that this acceleration was equivalent to the force of gravity. So, just as special relativity describes what happens in reference frames, or inertial frames, moving at some constant speed **(3) relative** to one another, gravity was a consequence of being in a reference frame that is accelerating. He called this the happiest thought of his life**. A** [_____].

[4] Talking through his ideas with trusted colleagues and using the latest mathematical formalisms to encapsulate them, he **(4) pieced** together the full theory of relativity that he called general relativity. The year 1915 when he published the work proved especially busy and almost immediately he revised it several times. His **(5) peers** were astounded by his progress. The theory even produced bizarre testable predictions, including the idea that light could be bent by a gravitational field and also that Mercury's elliptical orbit would rotate slowly because of the gravity of the Sun.

[5] In general relativity theory, the three dimensions of space and one of time are combined into a four-dimensional space-time **(6) grid**, or metric. Light's speed is still fixed, and nothing can **(7) exceed** it. **B**[_____].

[6] General relativity is the best imagined by visualizing space-time as a rubber sheet stretched across a **(8) hollow** table top. Objects with mass like weighted balls placed on the sheet. They depress space-time around them. Imagine you place a ball representing the Earth on the sheet. It forms a depression in the rubber plane in which it sits. **C** [_____]. This shows how it feels gravity. If the smaller ball was moving fast enough and the Earth's dip was deep enough, then just as a daredevil cyclist can ride around an inclined track, that body would maintain a moon-like circular orbit. You can think of the whole universe as a giant rubber sheet. Every one of the planets and stars and galaxies causes a depression that can attract or deflect passing smaller objects, rolling over the contours of a golf course.

[7] Einstein understood that, because of this warping of space time, light would be deflected if it passed near a massive body, such as the Sun. he predicted that the position of a star observed just behind the Sun would shift a little because light from it is bent as it passes the Sun's mass. **D**[_____]. It proved one of his greatest moments, showing that the theory some thought crazy was in fact close to the truth.

[8] The bending of light rays has now been confirmed with light that has travelled right across the universe. Light from very distant galaxies clearly **(9) flexes** when it passes a very massive region such a giant cluster of galaxies or a really big galaxy. The background dot of light is **(10) smeared out** into an arc. Because this mimics a lens the effect is known as gravitational lensing. If the background galaxy is sitting right behind the heavy **(11) intervening** object then its light is smeared

out into a complete circle, called an Einstein ring. Many beautiful photographs of this spectacle have been taken with the Hubble Space Telescope.

[9] Einstein's theory of general relativity is now widely applied to modeling the whole universe. Space-time can be thought of like a landscape, complete with hills, valleys and pot holes. General relativity has lived up to all observational tests so far. The regions where it is tested most are where gravity is extremely strong, or perhaps very weak.

[10] Black holes are extremely deep wells in the space-time sheet. **E** [_____]. They mark holes, or singularities, in space-time may also warp into worm holes, or tubes, but no one has actually seen such a thing yet.

[11] At the other end of the scale, where gravity is very weak it might be expected to break up eventually into tiny quanta, similar to light that is made up of individual photon building blocks. But no one has yet seen any graininess in gravity. Quantum theories of gravity are being developed but, without evidence to back it up, the unification of quantum theory and gravity is **(12) elusive**. This hope occupied Einstein for the rest of his career but even he did not manage it and the challenge still stands.

**4. Read the text again and find the words (in bold) that mean the same as the following phrases.**

a) Spread soft substance over a surface in a rough or careless way;
b) Considered and judged by being compared with something else;
c) Falls suddenly and quickly from a high level or position;
d) Put all the separate parts of something together to make a complete whole;
e) People of the same age or who have the same social status as somebody;
f) Coming or existing between two events, dates, objects;
g) Having a hole or empty space inside;
h) A pattern of straight lines, usually crossing each other to form squares;
i) To move slowly on the water or in the air;
j) Bends;
k) To be greater than a particular number or amount;
l) Difficult to find, define, or achieve.

**5. In pairs, discuss and write definitions for the following terms from the text. Use a dictionary to help you.**

*to warp*
*to shift*
*a plane*
*consequences*
*cluster*
*a dip*
*metric*
*to distort*
*gravitational lenses*
*deflect*
*reference frames*

**6. Choose the phrase that means the same.**

1) Incorporating gravity into his theory…
   a) adapting gravity to his theory;
   b) explaining gravity with the help of his theory;
   c) including gravity in his theory;
2) They depress space-time around them …
   a) they suppress space-time;
   b) they put down space-time;
   c) they crush space-time;

3) General relativity has lived up to all observational tests so far.
   a) it has remained as perfect as before;
   b) it has been developed;
   c) it has turned out to be as true as before;
4) The background dot of light is smeared out into an arc.
   a) the light turns into a curved band;
   b) the light looks like semicircle;
   c) the light obtains the semicircular shape;
5) The objects with mass are like weighted balls placed on the sheet.
   a) balls with measured weight;
   b) heavy balls;
   c) balls with definite weight.

**7. Read the sentences and mark (T) true or (F) false.**

1) Objects can't be free from gravity.
2) Gravity was a consequence of Einstein's special theory of relativity.
3) At that time it was impossible to test the general relativity theory.
4) Einstein claimed that space-time grid changes the speed of light.
5) Objects with large mass depress space-time around them.
6) An Einstein ring is a shape which light gets passing the massive space bodies.
7) The Hubble Space Telescope has helped astronomers to explore better the regions with weak gravity.
8) Space-time may warp into black holes or worm holes.
9) In space regions where gravity is weak it broke up into tiny quanta.
10) The unification of quantum theory and gravity is quite probable.

**8. Fill in the gaps with the new words in the correct form:**

**Part A**

*hollow, plummet, distort, shift, smear out, plane, peers, intervening, space-time, worm hole.*

1) Even the tiniest spot gets blurred because the light is _____as it passes through the eye or camera aperture.
2) When the rounded wavefronts reach the aperture _____, it cuts through them like a knife cuts through the layers of an onion sliced off centre.
3) Anything that falls within the event horizon _____into the black hole, including light.
4) If the _____space between us and a distant galaxy swells steadily as the universe expands.
5) The electrical field pattern set up with a Faraday cage – a _____conductor – means that all the charge is carried on the outside of the cage, and inside the cage it is completely neutral.
6) Newton's _____argued against it, preferring to believe that colors arose from combinations of white light and darkness, as a type of shadow.
7) That's because nothing can travel faster than the speed of light, so time and space themselves _____when approaching this universal speed limit.
8) The Lorenz attractor looks like a series of overlapping figures of eight slightly _____and distorted from one another, mirroring the shape of butterflies' wings.

9) If the tubes were joined together, then you could imagine a tube or _____being formed between the two mouths of the black holes.
10) It is a hole in the sheet of _____, like a basketball net.

**Part B**

*Resistance, exceed, metric, frame of reference, bend, float, relative, gravitational lensing, warp, general relativity.*

1) It is because light travels at different speeds in air and water, causing the rays to _____
2) Inertial frames are spaces that move _____to one another at a constant speed, without experiencing accelerations or forces.
3) A metal is a lattice of positive charged nuclei about which a 'sea' of electrons is free to …
4) In the event that the gravity _____the weight as for the largest stars, further contraction ultimately produces a black hole.
5) General relativity is a _____theory of gravitation.
6) Einstein deduced that there is no fixed _____in the universe.
7) We can measure mass in two different ways: either we weigh it or measure its _____to acceleration.
8) The _____of space-time around a black hole is more intense than anywhere else.
9) The equations of _____predict a number of phenomena many of which have been confirmed.
10) _____refers to a distribution of matter between a distant source and an observer, that is capable of bending the light from the source, as it travels towards the observer.

**9. Use the words given in brackets to form a word that suits in the gap**.

1) The Pauli exclusion principle explains why normal atoms cannot _____in the same region of space *(exist).*
2) _____are fluids that have no viscosity so they can flow through a tube forever without any friction *(fluid).*
3) At _____temperatures, group of bosons can behave very strangely *(cold).*
4) A single electron must follow Pauli's exclusion principle, that forbids such particles with _____ wave functions from sharing the same quantum state *(symmetry).*
5) The scientists designed a material that became a superconductor at temperatures of about 90 kelvins, warmer than the widely used _____liquid nitrogen *(cool).*
6) At very high temperatures, all the atoms in a magnet are disordered, their _____magnetic fields are all random and the material is not magnetic *(build).*
7) In 1961, Frank Drake wrote down an equation for the probability of a _____alien civilization living on another planet in the Milky Way *(contact).*
8) Radio astronomers are scouring nearby stars for signs of _____signals *(nature).*
9) The universe operates in _____ways, and we can only witness part of the picture at any time *(see).*
10) It could be that slightly _____amounts of each particle created in the Big Bang *(similar).*

**10. For each set find one word mentioned in the text that fits all sentences.**

**A**

1) Is she _____enough to travel?
2) The conference was very _____organized.
3) The sides of the _____are covered with brick or stone.

**B**

1) Shall I give you a _____?
2) I gave the porter a _____.
3) I had his name on the _____of my tongue.

**C**

1) He dug a deep _____in the garden.
2) The children climbed through a _____in the fence.
3) I am not going to bring up my child in this _____.

**11. Match the halves of the sentences**.

| | |
|---|---|
| 1) General relativity generalizes | a) More intense than anywhere else; |
| 2) The curvature of space-time is directly related to | b) Due to curvature of space-time around the massive Sun; |
| 3) The bending of light by gravity | c) A special relativity and Newton's law of universal gravity; |
| 4) Deflection of light has been confirmed | d) By observing the light of stars or distant quasars being deflected as it passes the Sun; |
| 5) Astronomically, the most important property of compact objects is | e) The energy and momentum of whatever matter and radiation are preserved; |
| 6) Light around a massive object, such as a black hole, | f) That they provide a supremely efficient mechanism for converting gravitational energy into electromagnetic radiation; |
| 7) The orbit of Mercury is shifting very gradually over time | g) Can lead to the phenomenon of gravitational lensing; |
| 8) Orbiting objects follow the path | h) Is bent causing it to act as a lens for the things that lie behind it; |
| 9) The planets move in ellipses, | i) The most energy-efficient path in the gravity well of the Sun; |
| 10) The warping of space-time around a black hole is | j) That is shortest and requires the least amount of energy. |

LISTENING

**12. Watch a video "General relativity under three minutes" Read the beginning of the sentences and choose the right ending, sometimes there are more than one.**

1) Einstein's Special theory only applies to bodies …
   a) in acceleration;
   b) at rest;
   c) in a constant state of motion;
2) Einstein returned to his theory to try to deal it with acceleration in …
   a) 1911;
   b) 1907;
   c) 1915;
3) Einstein supposed that gravitational mass and inertial mass …
   a) are the same;
   b) are similar to each other;
   c) are completely different;
4) Einstein hated that …
   a) there is no reliable theory to explain these phenomena;

b) two theories are needed to explain one phenomenon;
c) it is impossible to unite these two phenomena;

5) Einstein had the happiest thought of …
   a) The principle of equivalence;
   b) A person free falling in space who experienced gravity;
   c) Gravity which accelerates the object downwards;
6) General relativity theory is …
   a) connection between space and time;
   b) equivalence of inertia and gravitation;
   c) time slowing down with gravity;
7) He came up with a notion of the fabric of space and time as if it was
   a) trampoline fabric;
   b) stretching fabric;
   c) concave fabric;
8) the experiment with a bowling ball and billiard balls proves
   a) the action of gravitation on objects;
   b) the validity of four dimensional space;
   c) the action of gravitational waves.

SPEAKING

**13. Answer the questions.**

1) What is the significance of Einstein's general relativity theory for science?
2) What did Einstein call the happiest thought of his life?
3) How did Einstein come to his discovery?
4) What testable predictions did Einstein make with the help of this theory?
5) What is the essence of general relativity theory?
6) How can we imagine what space-time is?
7) What event convinced Einstein's peers in the validity of his theory?
8) How was the bending of light rays proved?
9) How did differences in the strength of gravity influence the universe?

**14. Read the sentences and mark (T) True or (F) False.**

1) Einstein's theory predicted that the direction of light propagation should be changed in a gravitational field.
2) The General theory of relativity predicts that light coming from a weak gravitational field should have its wavelength shifted to large values.
3) The gravitational field can have waves that carry energy and are called gravitational waves.
4) Gravitational waves are easy to detect because they are very strong.
5) Accelerating masses can emit gravitational waves.
6) The warping of space-time around a black hole is less intense than anywhere else.
7) The moon orbits the Earth not as a result of its inertial motion through the curved space-time, but because the Earth is pulling on it.
8) Einstein's theory predicted that the amount of space in the universe must be either increasing or decreasing.
9) Acceleration of an object in a gravitational field depends on its mass.
10) The inertial mass of any object is apparently identical to its gravitational mass.

15. **In groups, choose and tell about twelve things you must know about general relativity theory.**

16. **Answer the questions.**
    1) What is gravitational lensing?
    2) What is an Einstein ring?
    3) What is the principle of equivalence?
    4) What is gravitational mass?
    5) What is an inertial or unaccelerated system? Are they really the same thing?
    6) Is a freely falling observer in an inertial frame? Since such an observer feels no acceleration how does one handle the transformations between accelerated systems?
    7) Why is gravity fundamentally different from other forces?
    8) How exactly does curved space-time describe the force of gravity?
    9) What are the most important applications of the general relativity theory?
    10) When does light travel in a straight line and when does it travel in a curved space?

17. **Imagine: you are the teacher of the year. Tell your pupils about general relativity and be ready to answer their questions.**

18. **Explain this statement by Albert Einstein**
    *"If all accelerated systems are equivalent, then Euclidean geometry cannot hold in all of them"*

19. **Think of the word which best fits each. Use only one word in each space.**
    Einstein work 1_____how the laws of motion could be rewritten 2_____observers travelling 3_____different speeds. He ruled out the existence of a stationary frame of reference, 4_____as the ether, and stated that 5_____motion was relative with 6_____privileged viewpoint. If you are sitting on a train and see the train 7_____to you moving, you may know 8_____it is your train or the 9_____one pulling out. Moreover, even if you can see your train is stationary at the platform you can't assume that you are immobile, just that you are not moving relative to that platform. We 10_____feel the motion of the Earth 11_____the Sun; similarly, we 12_____notice the Sun's path 13_____our own Galaxy.

20. **Translate the paragraph into Russian**

GRAVITY WAVES

Another aspect of general relativity is that waves can be set up in the space-time sheet. Gravitational waves can radiate, especially from black holes and dense spinning compact stars like pulsars. Astronomers have seen pulsars' spin decreasing so they expect that this energy will have been lost to gravity waves, but the waves have not yet been detected. Physicists are building giant detectors on Earth and in space that use the expected rocking of extremely long laser beams to spot the waves as they pass by. If gravity waves were detected then this would be another coup for Einstein's general relativity theory.

**MINI GRAMMAR**

## ARTICLES

**21. Put *a/an, the* or *zero* in the spaces.**

If you could fly above 1 ____ mountains to 2 ____ top of 3 ____ atmosphere, perhaps out into 4 ____ space, 5____ pressure would drop to almost zero. 6 ____ perfect vacuum would not contain any atoms, but nowhere in 7 ____ universe is this true. Even in outer space there are sparsely spread atoms, numbering just 8 ____ few hydrogen atoms per cubic centimeter. 9 ____ Greek philosophers Plato and Aristotle did not believe that 10____ pure vacuum could exist.

**22. Use the right punctuation.**

1. Electronics has given us radio (…) telephones (…) television and what not.
2. The electrons which revolve about the nucleus do not follow random orbits (…) they fall into definite energy levels.
3. The shell (…) or energy level (…) closest to the centre carries a single electron or two electrons.
4. From series observations comes a beautiful description of the molecule (…) the numbers and states of the electrons (…) their energetic levels (…) and so on.
5. The vacuum is perfect (…) that it does not contain any other particles or atoms (…) but it must be noted that such a concept is purely imaginative.
6. Even at this extreme low pressure (…) many times smaller than that in a thermionic valve (…) there are about $10^{-13}$ molecules per cubic meter.

## WRITING

## DESCRIBNG GRAPHS AND TABLES

I. What are the purposes of describing tables and graphs?

They are the following:

a) To make it easier to understand the concepts by using a visual rather than by just using words;
b) To provide more exact details than is desirable in the text;
c) To provide information which is additional to that provided in the text.
d) To draw attention to the most important aspects of the information shown in the graph or table.

II. Understanding graphs and tables involves understanding the following details:
What is the information or data in the graph or table about?
What are the units of measurement used?
What is the area (place) involved?
What is the time-scale involved?
What is the purpose of the graph or table?

III. Instructions.
a) You are not asked to discuss the information, but generally to 'write a report describing' the information;
b) It is not necessary to write an introduction;
c) You do not need to write a conclusion which gives any kind of opinion about the significance of the information;

IV. So how do you begin? **There are three steps.**
Step 1: identify the main idea behind the graph or table. This will be the focus of your first sentence.

Step 2: consider the details of what is being shown – the units of measurement and the time frame – and decide how much you need to include.

Step 3: consider the language to use – the introductory expressions, the tenses of the verbs, the correct expressions of the time/or measurement etc.

V. What introductory expressions to use

**The graph/table shows/indicates/illustrates/reveals/represents**
**It is clear from the graph/ table**
**It can be seen from the graph/table**
**From the graph/table it is clear**

VI. Expressions of measurement

*Quantities*

**Amount, figure**, **the total quantity, the whole of the, the majority of, the maximum, the minimum**, **the total number, the whole amount**;

*Other measurements*

**Range, rate, level, degree, extent, ratio, proportion, percent, percentage, length, weight, distance, height, altitude, frequency, duration, volume, size;**

VII. Mathematical expressions

| | | |
|---|---|---|
| **half/halves n.** | **halve vb.** | **double n./vb.** |
| **triple n.** | **treble vb.** | **threefold adj.** |
| **quarter n./vb** | **multiply vb.** | **divide vb.** |
| **average adj./vb/n** | **total adj.** | **partial adj. equal adj./n** |
| **fraction n.** | | |

VIII. Common adjectives:

These are some of the more common adjectives, with examples of appropriate collocations:

| | |
|---|---|
| **high/low:** | **a high/low percentage large: a large number** |
| **great:** | **a great number;** |
| **significant:** | **a significant number/percentage/amount;** |
| **considerable:** | **a considerable amount/increase;** |
| **substantial:** | **a substantial increase/decrease;** |
| **major:** | **a major increase/ decrease;** |
| **steady:** | **a steady decrease** |

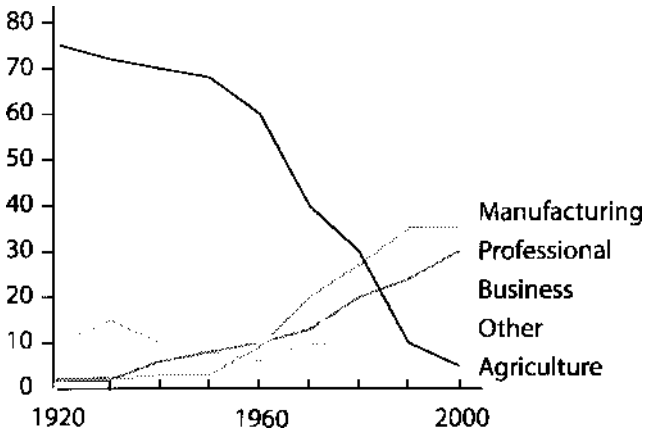
IX. Other parts of speech

Contrast and similarity can be shown by using specific, adjectives, and nouns:

| Verbs: | Adjectives: | Nouns: |
|---|---|---|
| **compare (with/to)** | **compared (with/to)** | **comparison in/with** |
| **contrast (with)** | **contrasting** | **contrast in/to** |
| **differ (from)** | **different (from)** | **difference ( between)** |
| **distinguish (between)** | **distinct (from) as** | **distinction (between)** |
| **resemble** | **same/the same as** | **resemblance (to/with)** |
| **-** | **similar (to)** | **similarity (with)** |
| **vary (from/between)** | **-** | **variation (between)** |
| **change (from/to)** | **-** | **change (from)** |

X. Fill in the gaps in the following description, using expressions from the above lists. Try to vary the expressions you use to avoid repetition.

Employment Patterns in Alia, 1920— 2000




In 1920, 75% of the labor force in Alia was employed in agriculture 1_____ only 10% worked in business and trade. At the same time 2_____ the manufacturing sector the professional sector 3_____ constituted just 2% of the workforce each. This situation changed only very gradually over the next 20 years, 4_____ the professional workforce, which increased more than threefold. 5_____ by 1970 there had been a significant change in the pattern of employment. 6_____ the agricultural employees had declined in number to 40% of the workforce, manufacturing employees 7_____ professionals had increased their share to 13% and 10% respectively. 8_____ the business sector did not increase until 1970. The most dramatic 9_____ could be seen by 1990, when the proportion of agricultural workers was reduced to just 10% 10_____ the three other major sectors had all increased to over 20% of the workforce.

## Grammar Reference

**THE INFINITIVE**

1. The infinitive can be the subject of the sentence, and translated as the infinitive or a noun.
   *To be* a materialist means to accept the primacy of matter.
   *To determine* the properties of the substance needs a lot of experiments.
2. As an object it the infinitive is used after the predicate.
   They have *to minimize* the disadvantages.
3. The infinitive can be an adverbial modifier.
   The form of the equation should be simple so as *to be* useful for the calculation.
4. As an attribute the infinitive is translated by a subordinate clause with the help of the following words: который, должен, нужно, можно.
   There are many considerations *to be taken* into account in determining space velocity.
5. As a parenthesis the infinitive is usually used at the beginning of the sentence with a comma after it.
   This is the list of most frequently used parentheses:
   **to begin (start) with -** прежде всего;
   **to judge by –** судя по, если судить по;
   **to make a long story short** – короче говоря;
   **to mention (only some)** – если упомянуть (лишь некоторые);
   **to name (only a few) –** если упомянуть (лишь немногие);
   **to put it another way** – иначе говоря;
   **to put it briefly** – короче говоря;
   **to put it mildly** – мягко выражаясь;
   **needless to say** – нет надобности говорить о…;
   **to say nothing of** - не говоря уже о… ;
   **suffice it to say** – достаточно сказать;
   **to be exact** – точнее говоря;
   **so to speak** – так сказать;
   **to sum up** – если подвести итог;
   **to quote (a single example)** – если привести (один пример);
   **to return** – если возвратиться;
   **to tell the truth** – по правде говоря.

The to-infinitive is used:

a) To express purpose. *To live* long it is necessary to live slowly (M. T. Cicero)
b) After certain verbs (**advise, agree, appear, decide, expect, hope, manage, offer, promise, refuse, seem, want, afford**, etc.) They decided *to check* the new device.
c) After adjectives such as **nice, glad, afraid**, etc. It was very difficult *to do* the calculations on time.
d) After **too** and **enough** Physicists haven't got enough data to understand this phenomenon.
e) After it + be +adjective (+ of + noun (pronoun) It is very important to discover any evidence for any graininess in gravity.
f) After **would like/ would love/would prefer** They would prefer to repeat the experiment in another mode.

The bare infinitive is used:

a) After modal verbs
*These vertices can be used to represent many different types of interactions.*
b) After the verbs **let, make, see, notice, hear and feel** but: be made/ be heard/ be seen + to +infinitive
*Feynman's diagrams let physicists to calculate the probability that the interaction will take place.*
c) After **had better** and **would rather**
*We had better follow some basic rules.*

Note: if two infinitives are joined by ***and,*** the ***to*** of the second infinitive can be omitted.

**TABLE A**

**Forms of the Infinitives**

| | Active Voice | Passive Voice |
|---|---|---|
| Present Simple | **( to) write** | **(to) be written** |
| Present Continuous | **(to) be writing** | |
| Present Perfect | **(to) have written** | **(to) have been written** |
| Perfect Continuous | **(to) have been writing** | |

**The Present Infinitive refers to the present or future**. e.g. To construct an experiment of this kind seems nearly impossible.

**The Present Continuous Infinitive expresses an action happening now**. e.g. Physicists seem to be struggling with this discrepancy.

**The Perfect Infinitive** is used to show that the action of the infinitive happened before the action of the verb. e.g. They claim to have seen larger particles behaving like waves.

**The Perfect Continuous Infinitive** is used to emphasize the duration of the action of the infinitive, which happened before the action of the main verb. e.g. They seem to have been computing all night.

**TABLE B**

**The verb tenses corresponding to the tenses of the infinitive are the follows**

| **Verb tenses** | **infinitive** |
|---|---|
| He goes/will go | **(To) go** |
| He is going/will be going | **(To) be going** |
| He went/has gone/had gone/will have gone | **To have gone** |
| He was going/has been going/had been going/ | **To have been going** |
| He will have been going | **To have been going** |

When the infinitive is used as a subject it can be translated as a noun or an infinitive:

e.g**. To think** otherwise would be a mistake **Думать** по-другому было бы ошибкой.

**To account for** these variations is in principle simple**. Объяснение** этих изменений в принципе простым.

When the infinitive is used as an attribute it is used after an object and it is translated with the help of a clause beginning with **'который'**; sometimes the adverbs, such as **должен**, **нужно**, **можно** will be useful.

e.g. The curves **to be presented** in this Part were obtained on single- crystal samples.

Кривые, **которые будут представлены** в этой части, были получены на образцах монокристаллов.

As a parenthesis, the infinitive is used at the beginning of the sentence and is separated from the rest of it by a comma.

e.g. **To sum up**, we will present the table **Подводя итог (чтобы подвести итог)**,приведем таблицу.

While translating such sentences you should use some connecting words like **следует отметить, необходимо упомянуть** and so on.

e.g. **To begin with**, no general method will be given here. **Для начала следует сказать**, что никакого общего метода здесь не будет дано.

EXERCISES

**1. Translate the sentences into Russian**.

1) To construct an experiment of this kind seems nearly impossible.
2) We attempted to carry out this investigation.
3) To perform this work one must have all the necessary equipment.
4) Rotation spectra can be used to measure bond lengths.
5) With these conditions there are also opposing factors to be considered.
6) It is too urgent a matter to be postponed.
7) Some molecules are large enough to be seen on the electron microscope.
8) Thomas was the first to focus attention on this type of reaction.

9) Two numbers –latitude and longitude, for instance are enough to fix your position.
10) The important thing is to understand what you are doing, rather than to get the right answer.

**2. Read the text and try to find infinitives in it and define its forms**.

Newton tried to understand the relationships between objects and movement by thinking about a spinning bucket of water. At first when the bucket is turned, the water stays still even though the bucket moves. Then the water starts to spin as well. Its surface dips as the liquid tries to escape by creeping up the sides but it is kept in place by the bucket's confining force. Newton argued that the water's rotation could only be understood if it can be seen in the fixed reference frame of absolute space, against its grid. We could tell if the bucket was spinning just by looking at it because we would see the forces at play on it producing the concave surface of the water.

**3. Change the sentences according to the model using *too* and the infinitive**.

*Example: The results are very numerous. They can't be summarized in this paper.*
*The results are <u>too</u> numerous <u>to be summarized</u> in this paper.*

1) The particle is so small that it cannot be seen.
2) This hypothesis is so doubtful that it cannot be discussed in this review.
3) This phenomenon is so rare that it cannot be satisfactorily explained.
4) The theory is so extensive that it cannot be given here.
5) The classification is so complicated that it cannot be used in practice.
6) The experiment is carried out so carelessly that it cannot be considered valid.
7) This problem is so complex that it cannot be solved at present.
8) The theoretical analysis is so complicated that it cannot be tested by experiment.
9) The data are so contradictory that they cannot be relied upon.
10) The applications of electricity are so numerous that they cannot be considered in this article.

**4. Choose the correct form of the infinitive**.

1. The direction of the magnetic force is found _____ different at different parts of the Earth's surface.

   a) to have been; b) to be; c)to being

2. For this reason it is hard _____ optimistic about the future of radiation as a method of treatment.

   a) To be enough; b) to have been; c) to be too

3. …the action of its weight we may suppose this point to be its centre of gravity.

   a) Eliminating; b)To eliminate; c)To have eliminated

4. The Sun appears to be a ball of yellow light too bright_____ directly.

   a) To be gazed at; b) to gaze at; c) being gazed at

5. The gamma rays proved_____ true waves like X-rays, but of much shorter wavelength.

   a) To have been; b) to be; c) being;

6. The immediate objective of the Apollo was_____ a man on the Moon and bring him back alive.

   a) to have landed; b) to be landed; c) to land;

7. The results appeared to be lacking precision. To get better results another method should_____

   a) to be applied; b) be applied; c) have been applied;

8. This means that one of these levels must_____ lower energy than before splitting.

a) have had; b) have; c) to have;

9. It turned out that a giant eruption of hot gases had taken place that day at the surface of the Sun, and it must_____ responsible for the strong radio signals coming from the west.

a) have been; b) be; c) to be;

**5. Complete the sentences using the words in bold and an infinitive.**

*e.g. The results are so contradictory. They can't **be used** in the article. (**too**)*

*The results are too contradictory to be used in the article.*

*e.g. The results of the experiments are reliable. They can **be used** in the further research.(**enough**)*

*The results of the experiments are reliable enough to be used in further research*

1) These experimental investigations were so complicated that the research team couldn't **get** any results for a long time. **(too)**

2) Cohesive forces are very strong. They can **keep** the molecules in their places. (**enough**)

3) The calculations are accurate. They can **be applied** in further research (**enough**)

4) The idea isn't clear. It can't **be formulated** exactly. (**enough**)

5) The point is quite trivial. It doesn't need **to be mentioned** (**too**).

6) The task is very difficult. It can't **be done** without some preliminary work.(**too**)

7) Electron microscope is very powerful. It allows the tiniest particles **to be observed**. (**enough**)

8) The classification isn't simple. It can't **be used** in practice. **(enough**)

9) The measurements are very accurate. They **contribute** the necessary information. (**enough**)

10) Both methods are very doubtful. They don't permit **complete** agreement with the theory. (**too**)

**6. (A) John Reeder is a young researcher. He is going to solve a scientific problem. Using the prompts given, say what he expects to do, as in the example.**

*e.g. He expects to recognize a problem.*

a) collect experimental facts or data;
b) analyze data;
c) set up a tentative hypothesis;
d) plan his own experiments;
e) analyze the results;
f) make some necessary calculations, graphs, tables;
g) modify the hypothesis.

**(B) John has finished the experiments. Things didn't happen the way he expected them to. Look at the prompts above again and make sentences as in the example**.

*e.g. He expected to have recognized the problem.*

**7. Fill in the correct infinitive form using table B.**

e.g. I think they obtained successful results. They must **have obtained** successful results.

2) I think Hooke contributed to many areas of science, from astronomy to biology, and even architecture. Hooke must…

3) I think physicists will need cleverer technology to reach colder temperatures. They may…

4) I think the reaction is going too quickly. The reaction must…

5) I think the energy of a moving object doesn't depend only on the mass of the object. It can't…

6) I think the results of the calculations were accurate. The results must…

7) I think speed and velocity are used to compute the kinetic energy. Speed and velocity must…

8) I think it is possible that they have been working on that project for a year. They may…

9) I think they have done a breakthrough in understanding the nature of black holes. They must…

10) I think I will be processing the obtained results when you finish your project. I may…

**8. Report these sentences using one of the verbs in brackets and an infinitive in a proper form.**

*e.g. Scientists think that Maxwell's equations **are** the most important advance since the universal theory of gravitation.(prove)*

Maxwell's equation **proved to be** the most important advance since the universal theory of gravitation

1) The astrophysicists predicted that the Sun initially **had** a metal-rich core. (**might**)
2) They are sure that hydrogen **was** originally in the score has now burnt out. (**must**)
3) Dr. G. R. Isaak reported that his team in Birmingham **have also detected** solar oscillations. ( **claimed**)
4) They think that the necessary technique **has been developed**. (**hope**)
5) The astrophysicists **are studying** gravitational red shifts in the solar system with this technique. (**must**)
6) Dr. Hill **has found** the periods of the Sun oscillations. (**claim**)
7) Dr. G.R. Isaac **has measured** the solar oscillations. (**prove**)
8) They **will provide** a mechanism for removing energy from the core, lowering the expected neutrino flux. (**might**)
9) They suggested it. The Sun **was formed** from chemically inhomogeneous material.(**may**)
10) Albert Einstein demonstrated that mass **is** a very concentrated form of energy. (**prove**)

**9. Complete the sentences with the infinitive so that they are true for you**.

1) I have recently decided to…
2) I'm flexible, but one thing I refuse to do is…
3) Five years from now, I hope…
4) I'm satisfied that I can afford…
5) I'm sure I will manage…
6) I confess that one thing I tend to do is…
7) I hope …
8) I want…
9) I expect…

**10. Practice to use different infinitives after modal verbs**.

1) Должно быть, он…
   He must be ill.
   He must be staying in the lab.
   He must have finished the computing.
   He must have been working since 8 a. m.
   Translate into English
2) Должно быть, он уже заполнил таблицу.
3) Возможно, он сейчас заполняет таблицу.
4) Должно быть, он заполняет таблицу после каждого считывания показаний приборов.
5) Возможно, он заполняет эту таблицу несколько часов.

**11. Answer the questions using the right form of the infinitive**.

1) Is the Sun producing a much lower or higher neutrino flux? (**seem**)
2) Did Richard Feynman watch the explosion of the nuclear bomb in Los Alamos? (**claim**)
3) Do photons carry information in electromagnetic interactions? (**must**)
4) Are the Higgs bosons more massive than other particles? (**appear**)
5) Is the photoelectric effect used today in solar panels? (**must**)
6) Does a light quantum transfer its entire energy to a single electron? (**seem**)
7) Are physicists still searching for a new theory to explain high temperature superconductivity? **(tend**)
8) Is a group of physicists trying to explain the pattern of fundamental particles by treating them as waves or a string? (**expect**)
9) Have scientists failed to reveal the true nature of the light? (**might**)
10) Did Einstein try to unify quantum theory and gravity? (**expect)**

**Subjective Infinitive Construction (Complex Subject)**

This construction is often used in scientific articles. It has the following pattern:

## I. Subject + passive + to-infinitive

*Radium **is known to be** very radioactive.* ***Известно, что*** *радий очень радиоактивен.*
*Beryllium **is found to have** four electrons.* ***Установлено, что*** *бериллий имеет четыре электрона.*

You can translate these types of sentences using ***говорят, известно, сообщается*****.** The infinitive of the English sentence becomes the predicate of the second part of the sentence. Use the conjunction ***что*** *to connect these two parts.*

**Forms of the Infinitives**

| | **Active Voice** | **Passive Voice** |
|---|---|---|
| Present Simple | *(to) write* | *(to) be written* |
| Present Continuous | *(to) be writing* | - |
| Present Perfect | *(to) have written* | *(to) have been written* |
| Perfect Continuous | *(to) have been writing* | - |

In this construction the following verbs are used in **Passive form**:

**(is) assumed** - полагать, предполагать
**(is) believed** - полагать, считать
**(is) considered** - считать
**(is) expected** - ожидать, предполагать
**(is) found -** находить, устанавливать
**(is) imagined** - предполагать, думать
**(is) known** -знать
**(is) reported** -сообщать
**(is) said -** говорить, сказать
**(is) shown** - показывать
**(is) supposed** - полагать, предполагать
**(is) proved** - доказывать

The other verbs that are used in such constructions are: **calculate, claim, discover, estimate, understand** etc.

*e. g. The spectrum **is said to be made of** hues.* ***Говорят, что** спектр состоит из оттенков.*

The predicate of the sentences with the subjective infinitive construction is mostly used in Passive but there are some verbs which are used with this construction **in Active**.

## II. Subject + active + to-infinitive

*e. g. The equilibrium potential for the process **appeared** not to change.*
***Казалось, что** потенциал равновесия для такого процесса не изменялся.*

This is the list of the most frequent verbs which are used **in Active**:

**To seem, to appear** - казаться;
**To prove, to turn out** - оказываться;
**To happen** - случаться, случайно оказываться;

## III. Subject + (to be) + adjective + to-infinitive

There are some expressions with **adjectives** translated into Russian as **adverbs** which act the same:

(is) **likely** - вероятно;
(is) **unlikely** - маловероятно;
(is) **apt** - возможно, вероятно;
(is) **sure, certain** - безусловно, наверняка;

*The latest discovery in this field **is likely to stimulate** the researchers' interest.*
*Последнее открытие в этой области, **вероятно**, повысит интерес ученых.*

- In such constructions the infinitive can have **a negative form**. "Not" is placed **before** to-infinitive. While translating the sentence into Russian, the predicate should have a negative form.

*It is likely **not to lead** to plan imbalance. Вероятно, это **не ведет** к разбалансировке плана.*
*The effect was considered **not to be** of any importance. Считалось, что этот эффект **не имеет** никакого значения.*

- In this construction the verb **to prove** can be used in two meanings: 1)To show sth is true; 2) to be. The choice of its translation depends on its form:

a) If **to prove** is used in **Active,** it has the second meaning:
*This **proved** to be false. **Оказалось**, что это была ложь.*
b) If **to prove** is used in **Passive**, it has the first meaning:
*This **was proved** to be false. **Было доказано**, что это ложь.*

**SUBJECT**

**1. Translate the text and find the examples of the Subjective Infinitive Construction.**

Benjamin Franklin is acknowledged to be the founder of the theory of atmospheric electricity.

At the time when theories to explain electricity were neither complete nor well founded the lightning was proved by him to be an electrical phenomenon. He was not the first to think of it but he was the first to prove it. His theory of electricity still appears to hold good. He is known to have invented a means of protection against the disastrous effects of lightning- the lightning rod. Franklin's theory at first was assumed to be misunderstood both in his country and abroad. It is known to have been severely attacked by the leader of French scientists Jean-Antoine Nollet.

Franklin is recognized to have been a great public figure who did as much as he could for the good of his country. He is known to have been the editor of one of the newspapers enjoying a great popularity with his countrymen. He is believed to be one of the broadest as well as one of the most creative minds of his time.

**2. Translate the sentences paying attention to the subjective infinitive constructions.**

1) People's knowledge is assumed to be well-organized and to facilitate the understanding of new information.
2) This process was expected to be more effective.
3) These stages are assumed to occur sequentially.
4) The data on the dispersion have been found to be in good agreement with the theoretical dispersion.
5) The approach was reported to apply.
6) From now on this model will be assumed to be adequate.
7) The talks are intended to give the latest advanced ideas in this field.
8) Such isomorphisms were shown to be linear.

**3. Choose the best way to complete the sentence.**

1) Oxygen … make 21% of the atmosphere.
   a) is seemed to;
   b) seems to;
   c) is seem to.
2) All the stars in the Milky Way … have personal names.
   a) are proved to;
   b) is proved to;
   c) proves to;
   d) prove to.
3) The earth's surface … receive energy from the sun at an enormous rate.
   a) is sure to;
   b) is sured to;
   c) sures to.
4) The earth's surface … a big mixture of all kinds of all atoms.
   a) is known being;
   b) known being;
   c) is known to be
5) The Egyptians and Assyrians appear to … some use of iron some centuries before the birth of Christ.
   a) make;
   b) made;
   c) have made.
6) Lead … in Rome in making pipes.
   a) is believed to use;

b) was believed to be used;
c) is believed to have been used.

7) Gold, silver, and copper … employed by Egyptians as early as 5000 B. C.
a) seem to have been ;
b) seemed to have been;
c) seem to have .

8) In 1820 a close connection between electricity and magnetism…
a) is certain to have discovered;
b) was certain to be discovered;
c) is certain to have been discovered.

9) Photons … interact very easily with particles of matter
a) is proved to;
b) are proved to;
c) proved to.

10) Neutrinos … take the speed of light.
a) is assumed to;
b) assume to;
c) are assumed to.

**4. Complete the sentences as in this example.**

**Example: It is expected** that **the data will fit** well with the observations.
**The data are expected to fit** well with the observations.

1) **It is known** that **magnetic field influences** plasma.
2) **It is believed** that **the equation is correct**.
3) **It is reported** that **the discussion will be concerned** with the semiconductors.
4) **It is known** that **the earth's surface receives** energy from the sun at an enormous rate.
5) **It is reported** that **essentially all of oxygen is chemically combined** with other substances.
6) **It is known** that **all the stars in the Milky Way do not have** personal names.
7) **It is predicted** that **the sun will become a cold, dead dwarf** in some billions or trillions of years.
8) **It is thought** that **the Moon sways** a little from side to side and also **nods** up and down.
9) **It is expected** that **unlimited solar energy may supply** a cheap, light-weight source of power for spaceships.
10) **It is proved** that **tungsten in small quantities makes** the steel very hard.

**5. Complete the sentences as an example.**

**Example**: People **think he was** a great scientist.
**He is thought to have been** a great scientist.

1) People **claim** that the **computers have relieved** the human beings of a great number of calculating tasks.
2) Scientists **think** that **some discrepancy was revealed** when they were comparing the results of two experiments.
3) They **know** that **he found** an error when he was making an additional check.
4) Scientific journals **report** that **they collected and synthesized** on the binding energy of nuclei.
5) Everybody **knows** that **the discovery** of **nuclear fission opened** the way to the great development.
6) Astronomers **predicted** that **the entire cosmos originated** from a single point.
7) Every physicist **knows** that **electromagnetic induction was discovered** by Michael Faraday.
8) Scientists **know** that **Maxwell measured** the speed of electromagnetic waves travelling through a vacuum.
9) Physicists **claim** that **Einstein** originally **tried** to unify quantum theory and gravity in the 1940s.
10) Astronomers **suppose** that one of Jupiter's moons, Europe,has been choed as a popular target for future searches for life in the solar system.

**6. Complete the sentences using the negative form of the infinitive and translate them into Russian.**

**e.g The results of these experiments …any practical use (prove/not/have)**

**The results of these experiments <u>prove not to have</u> any practical use.**

1) This technique … practical results (turn out/not/have).
2) The error … serious (prove/not/be).
3) In any event, current theories … for this result (appear/not/account).
4) Analysis shows that this is likely … any success (not/result).
5) The satellite is … on orientation relative to the sun or earth (certain/not/depend).
6) When we compared our data the discrepancy…obvious (turn out/not/be).
7) The radiation spectra … quite simple (prove/not/be).
8 ) Geiger counter is sure … for detection and measurement of velocity (not/use).
9) The carrier of the nuclear force is … the gluon (consider/not/be).
10) Mesons are … long half-lives (sure/not/have).

**7. Complete the sentences as in the example.**

***It is believed that*** *the extra dark matter* ***is*** *hundred of times more abundant than the visible stars and gas.*

*The extra dark matter* ***is believed to be*** *hundreds of times more abundant than the visible stars and gas.*

1) It is **expected** that gas in the outer regions **rotates** faster than it should if the galaxy was only as heavy as the combined mass of stars within it.
2) It is **known** that mass of dark matter **is detected** through its gravitational pull on other astronomical objects.
3) It is **thought** that the fate of the entire universe **depends** on its overall weight.
4) It is **expected** that dark energy **is** a form of energy associated with the vacuum of free space, causing a negative pressure in regions devoid of gravity-attracting matter.
5) It is **found** that dark matter **causes** regions of empty space to inflate.
6) It is **believed** that the universe **looks** the same in all directions.
7) It is **known** that Einstein's general relativity theory **describes** gravity as a warped sheet of space and time upon which light rays wend their ways along curved paths.
8) It is **assumed** that in reality, space-time **has** more dimensions but it is hard to imagine those.
9) It is **discovered** that the galaxies **do not concentrate** in one spot, they are littered in all directions.
10) It is **proved** that light **takes** 8 minutes to reach us from the Sun but 4 years from the next nearest star, Alpha Centauri to arrive.

**8. Complete the sentences as in the example.**

***It is known*** *that Johannes Kepler* ***was the first to notice*** *the paradox of the dark night sky in 17$^{th}$ century.*

*Johannes Kepler* ***is known to have been the first to notice*** *the paradox of the dark night sky in the 17$^{th}$ century.*

1) It is **known** that Edwin Hubble **used** the 100 inch Hooker Telescope at Mount Wilson to measure the light from flickering stars in the Andromeda nebula.
2) It is **believed** that astronomers **measured** hundreds of stars within the Milky Way before the 20$^{th}$ century.
3) It is **reported** that the Hubble Space Telescope **was launched** in 1990 from the space shuttle Discovery.
4) It is **thought** that Hubble **found** that the light from other galaxies was mostly redshifted by an amount that scaled with distance.
5) It is **supposed** that the expansion of the universe **began** in the big bang.

6) It is **assumed** that American physicist Alan Guth **developed** the theory of inflation.
7) It is **known** that astronomers found the evidence of black holes' existence before the 1960s.
8) It is **proved** that smaller black holes **were identified** by X-rays shining from gas falling towards them.
9) It is **supposed** that the birth of the universe in a phenomenal explosion **created** all space, time and matter.
10) It is **assumed** that space and time and matter **were all created** together in a cosmic fireball at the moment of ignition.

**9. Report the sentences using the subjective infinitive construction with the correct form of the infinitive.**

1) The scientists **have found** that relativity **applies** most of all to massive objects, like planets and stars and galaxies and matter across the entire universe.
2) Physicists **claim** that quantum mechanics **cares** about where and when a particle is located.
3) They **have discovered** that some black holes **emit** jets of particles.
4) They **think** that time **slows** down near a black hole.
5) We **suppose** that light beams travelling in the vicinity of the black hole **take** longer to travel across the curved space-time landscape, and reach us.
6) Physicists at the end of the 19$^{th}$ century **thought** that space **was effused** with a gas or 'ether' through which light radiates.
7) All physicists **know** that the most famous astronomers **gathered** to test Einstein's predictions by observing a total eclipse of the Sun on 29 May 1919.
8) They **say** that many beautiful photographs of this spectacle **have been taken** with the Hubble Space Telescope.
9) We **suppose** that black holes **are** extremely deep wells in the space-time sheet.
10) They **say** that space –time **warps** into worm holes, or tubes, but no one has actually seen such a thing yet.

**10. Change the sentences in this text using the subjective infinitive construction.**

A giant black hole has been located in the centre of our universe (prove). It has the mass of a million Suns squashed into a region just 10 million kilometres or so in radius (think). Astronomers have tracked the orbits of stars moving near the hole (report). The stars suddenly change course when they get close (find). These stars in the heart of the Milky Way move in strange ways around the black hole (believe). Black holes are the central engines in quasars(consider). Gas falling into the black hole becomes superheated and glows fiercely (assume). Stellar-mass black holes are also identified by detecting the X-rays from hot gas swirling around them (know). But black holes are not completely black (suppose). Some radiation escapes (think). Black holes slowly shrink because they lose energy as they radiate particles (find). They will evaporate away entirely (suppose).

**11. Change the sentences using the right form of the subjective infinitive construction.**

1) The beauty of the dark night sky **is becoming** harder and harder to see due to the glow of lights from our cities (say).
2) Stars like the Sun **live** for about 10 billion years (prove).
3) The universe **has only existed** for a limited amount of time, it is restricted in size (think).
4) The other galaxies **are** all **hurtling** away from us (consider).
5) The Hubble constant **has** an accuracy of about 10%, thanks to observations of galaxies with the Hubble Space Telescope and the cosmic microwave background radiation (know).
6) Galaxies **have been flying** apart since the explosion that created the universe (say).
7) Galaxies **have grown** over time due to gravity (believe).
8) Light **has no had** time to get from one side of the universe to the other (think).

9) Scientists **examined** the rocks from the moon but they are inanimate basalt (say).
10) Meteorites from Mars **host** the remnants of bacteria (imagine).

**12. Match the halves of the sentences.**

| | |
|---|---|
| 1. Alpha particles were found | a) to be the best method to observe the paths of alpha particles; |
| 2. Beta particles were proved | b) to be functioning very well; |
| 3. Becquerel is known | c)to move slower than beta particles; |
| 4. Radium and polonium are known | d)to be emitted by radioactive substances with a very high speed; |
| 5. Physicists are known | e)to have been designed; |
| 6. The Wilson Cloud Chamber is considered | f)to have made experiments with uranium; |
| 7. This device is proved | g)to have been discovered by the Curies |
| 8. The hydrogen atom is known | h)to consist of a positively charged nucleus and a single negatively charged electron; |
| 9. New types of reactors are reported | i)to have been trying for a long time to explain the structure of the nucleus; |
| 10. The atomic weights of over 600 isotopes are known | j) to have been measured with great accuracy. |

**13. Translate into English using the infinitive. Begin your sentence with the subject in bold.**

1) **Эксперимент**, кажется, уже завершился.
2) **Ученые**, как оказалось, не могли (не были способными) объяснить этот парадокс.
3) **Объяснение** этому парадоксу, кажется, найдено.
4) Известно, что **теория относительности** является очень важной в истории физики.
5) **Эта гипотеза**, как считается, не согласуется с экспериментальными данными.
6) Маловероятно, что в этой статье **термины** имеют четкие определения.
7) Как ожидалось, **законы притяжения** не действуют в космосе.
8) **Планеты**, как мы знаем, вращаются в одном направлении вокруг солнца.

## INFINITIVE AS AN OBJECT

There are several structures with infinitives when it functions as an object in a sentence. An object answers the question “(to do) what?”

You can translate these types of sentences using conjunctions ***что, чтобы, как***.

I. SUBJECT + **VERB** + to + Infinitive

The simplest example is when the infinitive follows the predicate.

*E.g.*

*Astronomers **attempted to collect** samples from asteroids.*

*Астрономы попытались (попытались сделать что?) собрать образцы с астероидов.*

This is the list of such verbs:

afford – позволить (приобрести себе)

agree – соглашаться

attempt – пытаться

decide – решить

deserve – заслуживать

expect* – ожидать

fail – не получаться, провалить

hope – надеяться

learn – научиться, обучаться

manage – справляться, удаваться

plan – планировать

pretend – притворяться

refuse – отказываться

promise – обещать

refuse – отказываться

wish/want* – желать, хотеть

II. SUBJECT + **VERB** + **SOMEBODY** + to + Infinitive

Some verbs need two objects 1) direct and 2) indirect. If there is a personal pronoun, it chances its form to the object one.

| | |
|---|---|
| I → me | we → us |
| you →you | you →you |
| he → him<br>she → her<br>it →it | they → them |

*E.g.*

*This **permits us to improve** the results.*

*Это позволяется нам (сделать что?) улучшить результаты.*

*He **warned them not to be violating** the safety rules in the lab.*

*Он предупредил их (о чём?), чтобы они не нарушали правила безопасности, находясь в лаборатории.*

This is the list of such verbs:

force smb to do smth – заставлять, вынуждать

| | |
|---|---|
| cause | smb to do smth – заставлять, вынуждать |
| lead | smb to do smth – заставлять, вынуждать |
| order | smb to do smth – приказать, обязать |
| require | smb to do smth – приказать, обязать |
| encourage | smb to do smth – сподвигать, вдохновлять |
| prefer | smb to do smth – выдвигать, предпочитать |
| advise | smb to do smth – советовать |
| recommend | smb to do smth – рекомендовать |
| tell | smb to do smth – сказать |
| ask | smb to do smth – сказать, попросить |
| remind | smb to do smth – напомнить |
| persuade | smb to do smth – убедить |
| instruct | smb to do smth – научить, поручить |
| teach | smb to do smth – научить |
| allow | smb to do smth – позволять |
| permit | smb to do smth – позволять, разрешать |
| enable | smb to do smth – давать возможность |
| forbid | smb to do smth – запрещать |

III. SUBJECT + **PERCEPTION VERB** + **SMB/SMTH** + ~~**TO**~~ + Bare Infinitive

SUBJECT + **make / let** + **SMB/SMTH** + ~~**TO**~~ + Bare Infinitive

After the verbs of perceptions and ***make*** and ***let*** a bare infinitive is used.

*E.g.*

*The scientist **saw the surface change** the color.*

*Учёный увидел (что?), как поверхность меняет цвет.*

*The gravitational forces **don't let the planets leave** the solar system.*

*Гравитационные силы не дают планетам (сделать что?) покинуть солнечную систему.*

Please, remember these verbs:

| | |
|---|---|
| hear | smb/smth do smth – слышать |
| see | smb/smth do smth – видеть |
| feel | smb/smth do smth – чувствовать |
| observe | smb/smth do smth – наблюдать |
| watch | smb/smth do smth – наблюдать |
| notice | smb/smth do smth – замечать |
| perceive | smb/smth do smth – ощущать, чувствовать |

| | |
|---|---|
| MAKE | smb/smth ~~**TO**~~ do smth – заставлять, вынуждать |
| LET | smb/smth ~~**TO**~~ do smth – позволять, разрешать |

**IV. COMPLEX OBJECT**

SUBJECT + **MENTAL OR STATE VERB (active)** + **SMB/SMTH** + to + Infinitive

| (a) подлежащее | (b) сказуемое | (c) дополнение | (d) инфинитив |
|---|---|---|---|
| ↓ | (ментальный глагол-состояние в активном залоге) | переводится подлежащим… | переводится сказуемым… |
| ↓ | ↓ | ↓ | ↓ |
| дают главное предложение | | … придаточного предложения | |

*E.g.:*

*We **have considered these processes to be** interconnected.*

*Мы считали до сих пор, что эти процессы взаимосвязаны.*

*He **showed the density to vary** within certain limits.*

*Он показал, что плотность меняется в определённых пределах.*

*We **believe our theory to be confirmed** by observations.*

*Мы полагаем, что наша теория будет подтверждена наблюдениями.*

This is the list of mental and state verbs which are used in the active voice:

| | |
|---|---|
| assume | smb/smth to do smth – делать допущение, условно полагать |

| | |
|---|---|
| believe | smb/smth to do smth – полагать |
| consider | smb/smth to do smth – полагать, рассматривать, считать |
| estimate | smb/smth to do smth – считать, оценивать |
| expect | smb/smth to do smth – полагать, ожидать |
| find | smb/smth to do smth – считать, находить |
| hate | smb/smth to do smth – считать неприемлемым |
| hold | smb/smth to do smth – считать, придерживаться мнения |
| know | smb/smth to do smth – знать |
| like | smb/smth to do smth – считать желательным |
| prove | smb/smth to do smth – доказывать |
| regard | smb/smth to do smth – считать, рассматривать |
| show | smb/smth to do smth – показывать |
| suppose | smb/smth to do smth – полагать, предполагать |
| take | smb/smth to do smth – считать, принимать (за) |
| think | smb/smth to do smth – полагать, думать |
| want | smb/smth to do smth – хотеть, чтобы |

You can translate these types of sentences with the help of ***чтобы*** /***что*** (sometimes ***как***).

*E.g.:*

| | |
|---|---|
| *We expect the scientist **to be involved** in the work.* | *Мы предполагаем, что этого ученого **привлекут** к этой работе (или: он **привлечен**).* |
| *We expect the scientist **to have been involved** in the work.* | *Мы предполагаем, что этого ученого **привлекли** к этой работе.* |
| *We expected the scientist **to be involved** in the work.* | *Мы предполагали, что этого ученого **привлекут/привлекают** к этой работе.* |
| *We expected the scientist **to have been involved** in the work.* | *Мы предполагали, что этого ученого **привлекали** к этой работе.* |

**1. Translate the text and find the examples of the Object Infinitive Construction.**

Men of science consider Lobachevsky to be a great mathematician. The whole world knows Lobachevsky to have strictly demonstrated and explained the principles of the theory of parallel lines. We consider him to be a great organizer of popular education, and we know him to have written much on the problems of education.

Lobachevsky was born on December 1, 1792 near Nizhny Novgorod. His father died when he was only a child, leaving the family in extreme poverty. The family moved to Kazan where Lobachevsky was

admitted to the gymnasium. We know his progress to have been extremely rapid in mathematics and classics. At the age of 14 he entered the University of Kazan where he is known to have spent 40 years as a student, assistant professor, and finally rector. Under his direction great improvements were made at the University. We know an observatory to have been founded and equipped and a mechanical workshop to have been established.

For 2200 years all the mankind believed Euclid to have discovered an absolute truth. Lobachevsky proved Euclid's axiom on parallel lines not to be true. He built a new geometrical theory quite different from that of Euclid. We know his ideas to have greatly influenced not only geometry, but mechanics, physics, astronomy as well. Like Galileo, Copernicus and Newton he is one of those who laid the foundation of science.

**2. Choose the best way to finish the sentence.**

1. My English teacher made …
a) me to translate this difficult article.
b) I translate this difficult article.
c) me translate this difficult article.

2. They managed …
a) examine the distribution of matter in the solar system.
b) us to examine the distribution of matter in the solar system.
c) to examine the distribution of matter in the solar system.

3. Collisions cause …
a) asteroids to be injected in orbits of planets.
b) asteroids be injected in orbits of planets.
c) asteroids to be injecting in orbits of planets.

4. We expect …
a) him to visualize this effect directly.
b) that he to visualize this effect directly.
c) him visualize this effect directly.

5. We know …
a) a magnetic field to have been influence the motion of an electron.
b) a magnetic field to be influenced the motion of an electron.
c) a magnetic field to influence the motion of an electron.

6. They refuse …
a) to have published their work.
b) to publish their work.
c) to be publish their work.

7. We know …

a) them to carry out the experiment just now.
b) they to be carrying out the experiment just now.
c) them to be carrying out the experiment just now.

8. My scientific adviser let …
a) me doing research work in his laboratory.
b) me do research work in his laboratory.
c) me to do research work in his laboratory.

9. They allowed …
a) to use their equipment.
b) to be using their equipment.
c) us to use their equipment.

10. I noticed … .
a) the substance to get warmer.
b) the substance get warmer.
c) that the substance get warmer.

**3. Correct the mistakes. Each sentence contains one mistake.**

1. One intriguing approach is to force the computer play games against itself.
2. The technique permitted problems to be solving.
3. This sequence causes to digitized images be stored in core memory.
4. We are interested in forcing the student making his own decisions from a wide range of choices.
5. We proving this suggestion to be wrong.
6. There were some reasons to believe it be the case.
7. Jordan supposed the statement to not be obvious and believed it to require a proof.
8. We shall consider a controller to being a system of reactors.
9. We expect the document serve to experienced programmers.
10. Aristotle supposes happiness to be associating with some other human activity.

**4. Change personal pronouns to their object forms.**

| | |
|---|---|
| I → me | we → … |
| you →… | you → you |
| he → …<br>she → …<br>it →it | they → … |

**5. Contradict the following statements by adding a direct object. Follow the model.**

*E.g.: He wants to perform the experiment (we). - No, he wants **us** to perform the experiment.*

1. The professor let her realize the importance of this data. (they)
2. He wants to interfere with their discussion. (we)
3. She wants to make a report at the meeting. (I)
4. The professor let them ask questions at any time. (he)
5. They want to participate in the meeting. (you)
6. The professor let us take part in the conference. (I)
7. He wants to study a wide spectrum of problems. (they)
8. She wants to prove the validity of this theory. (he)
9. I want to write a paper summarizing the studies of this effect. (she)
10. The professor let me read scientific literature. (we)

**6. Which pattern do these verbs follow?**

| ***A) VERB + to do*** | ***B) VERB + smb/smth to do*** | ***C) VERB + smb/smth do*** |
|---|---|---|
| 1. attempt | 6. learn | 11. order |
| 2. estimate | 7. let | 12. permit |
| 3. force | 8. hope | 13. promise |
| 4. want | 9. make | 14. recommend |
| 5. know | 10. notice | 15. see |

**7. Restate the given sentence using the word in brackets and the infinitive.**

1. My English teacher ordered me to attend lessons regularly. (make)
2. My scientific adviser allowed me to choose the best material for the experiment. (let)
3. Maxwell's equations helped physicists to predict the behavior of the electromagnetic field. (let)
4. They decided that they should go to the lab immediately. (agree)
5. My scientific adviser let me publish the results of our work. (allow)
6. Scientists believe that neutrino is the smallest particle. (think)
7. We know that publications on this phenomenon gave rise to heated discussions. (know)
8. My English teacher made me correct all the mistakes. (force)
9. We believe that the new device will serve the purpose. (consider)
10. We expect that the interaction pattern changes as a whole. (assume)
11. I watched how the stars were shining brighter. (notice)

**8. Turn the infinitive construction from Passive into Active using the new object in brackets. Do not lose the infinitive! Translate your final sentence into Russian.**

*E.g.: We expect **the students to be involved** in the work (scientists). → We expect **the scientists to involve** students in their work.*

1. High temperatures allowed the reaction to be carried out in two hours.(the team)
2. Such systems permit the properties of a particular machine to be exploited to the full. (we)
3. We expect the message to be transmitted by radio. (the team)
4. We know this effect to be studied directly. (the scientists)

5. We know the superconducting state of matter to be characterized by two fundamental properties. (the team)
6. They want this paper to be presented at the conference. (the scientists)
7. They believe this theory to have been proved a long time ago. (the team)

## INFINITIVES AS ADVERBIAL MODIFIERS

The infinitive can be an adverbial modifier of two types: purpose (for what?) and result (with what result?). The to+Infinitive frequently expresses **purpose**, indicating that one action will follow another, and can be made by putting *so as* or *in order* before the to+Infinitive. The idea of **result** or consequence is expressed in the pattern "the infinitive after adjectives".

**I. The infinitive expressing purpose**

(1) Conjunction ***in order to (для того чтобы)*** and ***so as to (так чтобы)*** are used before these infinitives in the beginning or the end of the sentences.

*E.g. The form of the equation should be simple so as to be useful for the calculation.*

*Форма уравнения должна быть простой (с какой целью?), чтобы быть удобной для расчетов.*

(2) To express a purpose another construction **for + noun + to + Infinitive** (***для того, чтобы сущ.+глагол)*** can be used.

*E.g.* ***For a force to exist*** *two objects must be involved.*

*(Для того) Чтобы существовала сила, необходимо вовлечь два объекта.(необходимо вовлечь два объекта с какой целью?)*

**1. Choose the best way to finish the sentence.**

1. We have to use spectral analysis …

a) to be determine the composition of materials.
b) to have determine the composition of materials.
c) in order determine to the composition of materials.
d) to determine the composition of materials.

2. We have to use this equation …

a) to specify the value.
b) specifying the value.
c) to be specifying the value.
d) to specified the value.

3. We should leave out the details…

a) in making the comparison easier.
b) in make the comparison easier.
c) in order to make the comparison easier.
d) to order the comparison easier.

4. The laboratory must have up-to-date equipment …

a) to have ensured effective research work.
b) to ensure effective research work.
c) to be ensured effective research work.
d) to be ensure effective research work.

**2. Restate the given sentence using the word in bold.**

1. The experimenter used a simple scheme so that he wouldn't have any problems.

**avoid** The experimenter used _____

2. We had to work hard because we were interested in the difference between the experimental results and theoretical predictions.

**compare** We had to work hard _____

3. You should look this term up in the textbook if you want to know the exact meaning of it.

**find out** You should look this term up _____

4. If you knew this topic better, you would enjoy his presentation at the conference.

**appreciate** You should know this topic better _____

5. When we obtain experimental data, we will prove this theory.

**verify** We need to obtain _____

**3. Identify the type of the infinitive construction and translate into Russian.**

1. Was any new scheme developed to classify these particles?
2. A thorough investigation is required to solve the problem.
3. For this value to be specified one must use a new set of equations.
4. What should we apply for these figures to be checked?
5. What should we do to confirm our hypothesis?

**4. Correct the mistakes. Each sentence contains one mistake.**

1. This article is given for students to reading at home.
2. For the effect to be understand, we have to consider it in detail.
3. No opportunity was created consult with a leading scientific group.
4. To be accounted for these observations we use a new model.
5. They had to examine the instrument carefully for the defect to be finding.

**5. Turn the infinitive construction from Active into Passive or vice versa, from Passive into Active. Do not lose the infinitive! Translate your final sentence into Russian.**

1. For the system to operate one should control the temperature.
2. For the article to be published she must put all tables in order.
3. For the procedure to be simplified they have to leave out unnecessary details.
4. To solve this problem they divided it into two steps.
5. To avoid this problem we used the latest scheme.

**6. Translate from Russian into English using the infinitive construction expressing PURPOSE and "for" where necessary.**

1. Что мы должны делать, чтобы эксперимент длился меньше времени? (active)
2. Чтобы схема была применимой в этом эксперименте, они изменят некоторые её части. (passive)
3. Чтобы улучшить результаты, мы должны сделать расчёты более точными. (active)
4. Чтобы измерить плотность, (нам) нужно изучить свойства этого вещества. (active)
5. Чтобы плотность могла быть измерена, (нам) нужно изучить свойства этого вещества. (passive)
6. Чтобы поддерживать магнитное поле, нужно использовать мощный магнит.
7. Чтобы магнитное поле могло поддерживаться, нужно использовать мощный магнит.

**7. Identify the infinitive construction. Translate that part of a sentence orally.**

1. The exhibition is taking place to celebrate the 70th anniversary of Russian atomic development and will take place from September 1-29 at the Manege Exhibition Hall, just a stone's throw away from the Kremlin and Red Square.
2. The Americans soon arrived on the scene to evaluate Irbene's past capabilities. They were impressed by the scale of the installation and nonplussed by the deliberate damage inflicted.
3. On June 10, 2015, a renovated and repainted 32-meter antenna (RT-32) was mounted on a 25-meter tower to become a radio telescope for scientific purposes.
4. To look deeper into Earth's past, the team went to the Jack Hills region of Western Australia, which is famous for its four-billion-year-old zircon crystals.
5. The scientists used a high-resolution magnetometer to measure faint magnetic signals of iron-bearing minerals trapped inside 25 zircons.

## The infinitive expressing result

The infinitive of result is usually placed at the end of the sentence and is preceded by adjectives or adverbs together with the words ***too (слишком), enough (достаточно), sufficiently (достаточно).***

**(1) too + adjective + to +Infinitive**

*E.g. The relativity principle is **too broad to be fitted** into a narrow scheme.*

*Принцип относительности слишком обширен (с каким следствием?), чтобы его можно было включить в эту узкую схему.*

**(2) adjectives + enough+ to +Infinitive**

*E.g. The energy is high enough to induce the process.*

*Уровень энергии довольно высок (и как следствие), чтобы начать процесс.*

**(3) enough + noun + to +Infinitive**

*E.g. We have enough energy to start the experiment.*

*У нас достаточно энергии (с каким результатом?), чтобы начать эксперимент.*

**(4) too + adjective + for smb/smth + to +Infinitive**

*E.g. The model is **too difficult for them to apply.***

*Эта модель слишком трудна, чтобы они могли ее применить.*

**1. Choose the best way to finish the sentence.**

1. Radioactive isotopes …

a) are dangerous enough to be used in people's bodies.
b) are enough dangerous to be used in people's bodies.
c) are too dangerous to be used in people's bodies.
d) so dangerous to be used in people's bodies.

2. The pressure force of magma pools can be …

a) too enough to crack thick layers of rock.
b) too strong to be cracked thick layers of rock.
c) strong enough to be cracked thick layers of rock.
d) strong enough to crack thick layers of rock.

3. The level of radiation is …

a) too high to living here.
b) enough high to live here.
c) too high to live here.
d) too high to be lived here.

4. The relativity principle is …

a) too broad to be fitted into a narrow scheme.
b) broad enough to be fitted into a narrow scheme.
c) too broad to be fit into a narrow scheme.
d) broad enough to fitted into a narrow scheme.

5. The professor is …

a) competent enough providing answers to their questions.
b) too competent to be provide answers to their questions.
c) competent to provided answers to their questions.
d) competent enough to provide answers to their questions.

**2. Identify the infinitive construction and the voice (Active or Passive). Translate the sentences into Russian.**

1. The energy is high enough to induce the process. (active/passive)
2. This model is too primitive to be used in our tests. (active/passive)
3. This scheme is too difficult for them to apply. (active/passive)
4. This error is too big to be neglected. (active/passive)
5. The ideas are too old to be discussed now. (active/passive)

**3. Combine two sentences using the word in bold and the infinitive of result.**

1. The theory is complicated. It cannot be described on a few pages.

**too** The theory _____

2. The description is elementary. It shouldn't be used for our purpose.

**too** The description _____

3. The device is quite precise. It should be used in our measurements.

**enough** The device _____

4. The results are pretty reliable. They can be used for further work.

**enough** The results _____

5. Supervolcanoes are very large thus they cannot be over pressurized all the time.

**too** Supervolcanoes are _____

**4. Correct the mistakes. Each sentence contains one mistake.**

1. This question is to serious to be answered at once.
2. This method is too complicated to be use by students.
3. This work is promising enough to stop it at this stage.
4. The temperature is too low to be using for the reaction.
5. This device is too old to repaired.

**5. Translate from Russian into English using the infinitive construction expressing RESULT and "too" or "enough" where necessary.**

1. При поражении электричеством именно значение силы тока делает электричество достаточно опасным, чтобы убить живой организм.
2. Критики также говорят, что наука слишком сложна, чтобы эффективно преподавать её в школах.
3. Калий слишком опасен, чтобы обращаться (с ним) без защитных перчаток.
4. Таким образом, гены достаточно сильны, чтобы управлять фенотипом.
5. Первый контакт с этим веществом слишком непредсказуем, чтобы использовать его сейчас.

**6. Identify the infinitive construction. Translate that part of a sentence orally.**

1. But needless to say it would be very, very expensive and very, very dangerous --- too dangerous to even contemplate production on earth even if we could afford it (which we can't).
2. But these rocks are difficult to analyze because they were re-heated around 2.6 billion years ago, which left a record of magnetic activity then that partially overlaid older evidence.
3. However, some people actually believe that science is too difficult to teach in schools and should be eliminated from the subjects which are mandatory to teach.
4. Teachers are very capable to teach science and with a skilled teacher most scientific concepts are not too hard for students to grasp.
5. Computer programs are too difficult to read and to modify, says physicist Kenneth Wilson, who is devising a better way.

**INFINITIVE AS AN ATTRIBUTE**

**The infinitive as an attribute (which? what? = какой? который?)**

We can use the infinitive in the function of an attribute. In this case the infinitive stands after the noun which it defines.

(1) You can translate these sentences with the help of the conjunctions ***который, кто***. Present infinitives should be translated with Russian verbs in the future tense or using ***должен, нужно, можно.***

*E g. The curves **to be presented** in this chapter were obtained on laboratory samples.*

*Кривые, **которые будут представлены** в этой части, были получены на лабораторных образцах.*

*E.g. The scientific **conference to be held** next year will tackle both experimental and theoretical aspects of research into plasma phenomena.*

*Научная **конференция, которая будет проведена** в следующем году, обсудит вопросы теоретических и экспериментальных исследований в области плазмы.*

(2) In the English language you can easily transform a part of the sentence into an infinitive construction omitting conjunctions **which**, **who**, **what.**

*E g. He was the first **who mentioned** this term. (active)*

*He was the **first to mention** this term. (active)*

*E g. The question, **which will be discussed** at the next seminar, will concern our current work. (passive)*

*The question **to be discussed** at the next seminar will concern our current work. (passive)*

- Mind the difference in meaning: *I have a question to discuss / to be discussed.*

**1. Choose the best way to finish the sentence.**

1. This is the scheme …
    a) to be made use of.
    b) to making use of.
    c) make use of.
    d) to be make use of.

2. The properties of the substances …
    a) to be studying are interesting.
    b) to study are interesting.
    c) to have studied are interesting.
    d) to be studied are interesting.

3. We can obtain more detailed information about the phenomena …
    a) to be studying.
    b) to be studied.
    c) to study.
    d) to have studied.

4. The methods … are numerous.

a) to apply for our purpose
b) to be apply for our purpose
c) to have apply for our purpose
d) to be applied for our purpose

5. They have many topics … at the conference.

a) to discuss
b) to be discuss
c) to be discussing
d) to be discussed

**3. Identify the infinitive construction and the voice (Active or Passive). Translate the sentences into Russian.**

6. They had much work to do yesterday. (active/passive)
7. The articles to be devoted to such substances may attract great interest. (active/passive)
8. Bohr was the first to use a structural model of the atom in his research. (active/passive)
9. The materials to be required for our investigation are difficult to get. (active/passive)
10. We have some difficulties to overcome. (active/passive)

**4. Restate the given sentence using the word in bold.**

1. It was Maxwell who created the electromagnetic theory.

**the first** Maxwell _____

2. He must solve a lot of problems with this experimental setup.

**to solve** He has _____

3. Our students have to take four exams in winter.

**to take in winter** Our students have _____

4. There is a gap in your knowledge which should be filled.

**to be** There is a gap _____

5. It was Hertz who verified the theory of electromagnetic waves.

**to verify** Hertz was _____

**5. Correct the mistakes. Each sentence contains one mistake.**

1. We are talking about a single experiment to performed multiple times.
2. I will manage this project if the respective data to be analyzed reliable.
3. This theory would be the last to be learning.
4. Faraday was the first to be introduce the field concept to physics.
5. I had this long article to be translating.

**6. Translate from Russian into English using the infinitive construction expressing ATTRIBUTE and "the first/last" where necessary. Do not use relative pronouns "which" or "that".**

1. Он был последним, кто покинул лабораторию вчера.
2. Данные, которые нам нужно проанализировать, относятся к концу XX века.
3. У него есть некоторые трудности, которые нужно преодолеть.
4. Этот навык - первый, который должен быть изучен.
5. У профессора есть много вопросов, которые нужно рассмотреть на собрании.

**7. Identify the infinitive construction. Translate that part of a sentence orally.**

1. The Greeks were the first to subdivide and name branches of science in a recognizable way, including physics, biology, politics, zoology and, of course, poetry!
2. The Tsar Bomba hydrogen bomb is the largest-ever nuclear device to have been detonated.
3. However, Dr Lane will be the last to collect the Royal Society prize.
4. My scientific adviser is describing in detail the design of experiment to be performed.
5. The proposed international Deep Underground Neutrino Experiment, to be based at Fermilab, will be the world's largest experiment for neutrino science and proton decay studies.

**8. Identify the type of the infinitive construction (Purpose, Result, Attribute) and translate into Russian.**

**P = Purpose R = Result A = Attribute**

1. For this value to be specified one must use a new set of equations.
2. Is this equation too hard for you to understand?
3. A thorough investigation is required to solve the problem.
4. The curves to be presented in Part 5 were obtained on single-crystal samples.
5. Is this workplace comfortable enough for you to conduct the experiment?
6. This task is too complex to be solved within an hour.
7. There are many considerations to be taken into account in determining space velocity.
8. Was any new scheme developed to classify these particles?
9. What should we apply for these figures to be checked?
10. He was the first to realize the difficulty of the situation.
11. This explanation is too confusing to be accepted.
12. This spacecraft is large enough to welcome aboard one more crew member.
13. What should we do to confirm our hypothesis?
14. The paper to be reported soon will be interesting.

**9. Identify the infinitive construction and its type (Purpose, Result, Attribute). Translate this part of a sentence orally.**

**P = Purpose R = Result A = Attribute**

1. Aristotle, regarded as the father of science, was the first to realize the importance of empirical measurement, believing that knowledge could only be gained by building upon what is already known.
2. But David Grinspoon, a researcher at the Planetary Science Institute in Tucson, Arizona, is not convinced that a planet must have an active magnetic field in order to be habitable.

3. But in this case the magnetic chain turned into a special type of superconductor in which electrons next to one another in the chain coordinated their spins to simultaneously satisfy the requirements of magnetism and superconductivity.
4. But it turned out that the materials to make a magnetic wormhole already exist and are much simpler to come by.
5. But to really speak of full proof, unambiguous evidence, I think you have to do a DNA test.
6. Herophilos (335–280 BC) was the first to base his conclusions on dissection of the human body and to describe the nervous system.
7. In medicine, Hippocrates (c. 460 BC – c. 370 BC) and his followers were the first to describe many diseases and medical conditions and developed the Hippocratic Oath for physicians, still relevant and in use today.
8. A towering structure rising 20 kilometers into the air with its top in the sky may sound like something out of an Old Testament passage or science fiction novel, but a Canadian space company has proposed just that to cut the costs of space exploration.
9. One of the great virtues of their platform relative to earlier works is that it allowed the researchers to apply a new type of microscope to probe the detailed anatomy of the physics.
10. One of the primary goals of the project was to create a bio-printable blood supply complex enough to effectively deliver oxygen and nutrients to all of an organ’s cells.
11. Thales' student Pythagoras of Samos founded the Pythagorean school, which investigated mathematics for its own sake, and was the first to postulate that the Earth is spherical in shape.
12. That failure to recognize the limitations of our knowledge produces partial understanding that is just not complex enough to be useful.
13. The advantage of employing this shape in the present experiment is that it is simple enough to fashion, yet complex enough to throw quite distinctive shadows.
14. The condensed formula only needs to be complex enough to show at least one of each ionic species.
15. The IceCube Neutrino Observatory employed 86 optical sensors buried 8,000 feet into the polar ice to detect light from high-energy neutrinos that, at the speed of light, pass through most mass with ease.
16. The LNT is the basis for regulations that assume that any radiation dose, no matter how low, is dangerous enough to avoid.
17. The other two layers acted to conceal the field's existence.
18. To confirm the finding, researchers then had to prove the neutrinos were not coming from within our galaxy, such as from the sun.
19. We will discuss the first O-Wing experiment to be conducted and logistics of test flying
20. You can be bad at this type of math by being imprecise/not detail-oriented, having a hard time memorizing things that are structured as step-by-step instructions, finding the subject too boring to invest any time in.

# Appendix

Writing a Scientific Summary (rendering)

**SUMMARY MUST HAVE:**

- the source
- the paraphrased main idea of the original
- the major supporting points
- the major explanations (reasons, causes, effects)
- the description of methods and results
- reporting verbs, mainly in the Active voice
- must be written in Present Simple or Past Simple
- specific, concrete language

**SUMMARY <u>DOES NOT</u>:**

- have specific examples or details (a lot of dates, numbers, statistics)
- express your opinion
- use original sentences
- exceed 1/3 length of the original
- suffer from wordiness

FRAMES to BEGIN

1. **In his/her article** (<u>title</u>)**,** (<u>author's name</u>) **argues / claims /reports/ states that**(<u>main idea</u>)

2. **According to the article** (<u>title</u>) **,** (<u>author's name</u>) **discusses** (<u>main topic/problem</u>).

3. (<u>author's name</u>)**'s article** (<u>title</u>) **describes / deals with** (<u>main topic/problem</u>).

4. (<u>author's name</u>) **, in his/her article** (<u>title</u>) **, argues that** (<u>main idea/argument</u>).

OTHER REPORTING VERBS

| | |
|---|---|
| **The article** | presents / reports on / deals with / focuses on / covers / describes / summarizes |
| **The author** | states / claims / argues / concludes / suggests / points out + **THAT** … |

| | |
|---|---|
| | criticizes / describes / points out + **SMTH** |
| | continues / goes on + **WITH** … |
| **The researchers** | state / claim / prove / report / analyze … |
| **The results** | support / fail to find support for … |

LINKING WORDS/CONNECTORS

| | |
|---|---|
| the author begins with | finally |
| first, second, third, last | thus |
| moreover / next / in addition | the author concludes that |

## Bibliography