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Учебно-методическое пособие по английскому языку “SCIENTIFIC READING” предназначено для студентов, обучающихся по направлениям подготовки «Физика», «Прикладная математика и физика», «Физика, химия и механика материалов», «Информационные системы». Целью настоящего пособия является развитие умений и навыков, необходимых для чтения и понимания литературы по специальности. Для обучения чтению подобраны оригинальные тексты из области физики, химии, математики, информатики. К текстам даны разнообразные задания, расширяющие словарный запас, закрепляющие наиболее часто встречающие грамматические конструкции. Полученные знания помогут в дальнейшей профессиональной деятельности.

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ПРЕДИСЛОВИЕ

Владение иностранным языком по разным направлениям востребовано в современном мире в связи с расширением межкультурных контактов, международной экономической и образовательной интеграции, мобильности и распространением научно-технических знаний. Радикальная переоценка высшего языкового образования придает предмету “иностранный язык” статус важнейшего стратегического ресурса. Безусловно, актуально формирование у обучающихся способности к стратегической детерминации будущего, ответственности за него, веры в себя и в свои профессиональные способности, способности к творческой самореализации, стратегическому проектированию вектора своей профессиональной карьеры, к социальной мобильности, к нравственной саморегуляции.

Данное учебно-методическое пособие рекомендуется использовать как для аудиторной, так и для внеаудиторной работы студентам первых и вторых курсов очной формы обучения, обучающихся по направлениям подготовки “Физика”, “Физика, химия и механика материалов” , “Прикладная математика и физика”, “Информационные системы”.

Пособие отражает лексические и грамматические явления, вызывающие затруднения при чтении научно-технической литературы на английском языке; тексты сопровождаются системой языковых и речевых упражнений, направленных на развитие навыков чтения, понимания, обсуждения, реферирования, перевода специализированных текстов, расширение словарного запаса по темам, связанным с различными аспектами научной сферы. Каждый текст сопровождается упражнениями, словами и выражениями, подлежащими активизации.

Теоретический компонент представлен заданиями для самостоятельной работы студентов. Тексты подобраны с учетом профиля специальности, отличаются актуальностью и высокой информативностью.

Целью пособия является формирование речевых компетенций, навыков устного и письменного общения на английском языке в сфере науки, перевода, реферирования, резюмирования, поискового и ознакомительного чтения оригинального англоязычного материала; формирования навыков понимания сообщений компьютера, спецификации и руководств по применению программных пакетов, умения беседовать на профессиональные темы, развитие умения читать специальную литературу разной степени сложности и извлекать из нее информацию.

В построении учебных указаний учтены современные требования методических концепций для учебников по иностранным языкам. Специальная терминология соответствует ключевым понятиям языка специальности.

SCIENCE AND TECHNOLOGY

In recent years, scientific and technological developments have drastically changed life on our planet as well as our views both of ourselves as individuals in society and of the Universe as a whole.

Today, science and technology are closely related. Many modem technologies such as nuclear power and space flights depend on science and the application of scientific knowledge and principles. Each advance in pure science creates new opportunities for the development of new ways of making things to be used in daily life. In turn, technology provides science with new and more accurate instruments for its investigation and research.

Technology refers to the ways in which people use discoveries to satisfy needs and desires, to alter the environment, to improve their lives. Throughout human history, men and women have invented tools, machines, materials and techniques, to make their lives easier.

Of course, when we speak of technology today, we are looking at it in a much narrower sense. Generally, we mean industrial technology, or the technology that began about 200 years ago with the development of power-driven machines, growth of the factory system, and mass production of goods that has created the basis for our modem society. Today we often say that we live in an age of science and technology. According to one estimate, 90 % of all the scientists who ever lived, were alive and active in the 1970-s. This increased scientific activity has brought new ideas, processes, and inventions in ever-growing amount. The scientific revolution that began, in the 16th century was the first time that science and technology began to work together. Thus, Galileo, who made revolutionary discoveries in astronomy and physics, also built an improved telescope and patented a system of lifting water. However, it was not until the 19th century that technology truly was based on science and inventors began to build on the work of scientists. For example, Thomas Edison built on the early experiments of Faraday and Henry in his invention of the first practical system of electrical lighting. So too, Edison carried on his investigations until he found the carbon filament for the electric bulb in a research laboratory. This was the first true modem technological research.

In a sense, the history of science and technology is the history of all humankind.

WORDS TO BE REMEMBERED

science and technology	наука и техника
technology	техника, технология
scientific and technological developments	достижения науки и техники
to drastically change the life	резко изменить жизнь
a view of	взгляд на
the universe	Вселенная
to be closely related	быть тесно связанным
nuclear power	атомная энергия
a space flight	космический полет
an application of scientific knowledge and principles	применение научных знаний и принципов
an advance in pure science	прогресс в чистой науке
to create new opportunities for	создать новые возможности для
an instrument for investigation and research	инструмент исследований
to satisfy needs and desires	для удовлетворения нужд и потребностей
to alter the environment	изменить окружающую среду
to improve one's life	улучшить чью-либо жизнь
throughout human history	на всем протяжении истории человечества

to invent tools, machines, materials and techniques	изобретать инструменты, машины, материалы, технологии
to make one's life easier	облегчить чью-либо жизнь
- to look at smth in a narrower sense	посмотреть на что-либо в более узком смысле
industrial technology	промышленная технология
development of power-driven machines	развитие паровых машин
growth of the factory system	рост фабричной системы
mass production of goods	массовое производство товаров
to create the basis for	создать основу для
an age of science and technology	век науки и техники
According to one estimate	по одной оценке
Increased scientific activity	возросшая научная активность, деятельность
an invention	изобретение
the scientific revolution	научная революция
to make a revolutionary discovery in astronomy and physics	сделать революционное открытие астрономии и физике
to patent smth.	запатентовать изобретение
to be based on science	основываться на науке
an inventor	изобретатель
to build on the work of scientists	основываться на научных работах

early experiments	ранние эксперименты
electrical lighting	электрическое освещение
to carry on an investigation	проводить исследование
electric bulb	электрическая лампочка
a research laboratory	исследовательская лаборатория
modern technological research	современное научно-техническое исследование

Ex 1. Answer the questions:

1. What role has scientific and technological development played in man's life?
2. What proves that science and technology are closely related today?
3. What does the term «technology» refer to?
4. What does the term «industrial technology» mean?
5. How is scientific activity in the 1970-ies estimated?
6. What facts prove that the scientific revolution of the 16th century was he first time that science and technology began to write together?
7. What was the first true modem technological research?
8. How can the history of humankind be described?

Ex. 2. Translate into English:

1. За последние годы наши взгляды на жизнь на Земле, на человека как личность, на Вселенную резко изменились.
2. Современная техника зависит от достижений в области чистой науки.
3. Техника дает науке более точные инструменты исследования.
4. Развитие науки делает возможным использование открытий для удовлетворения нужд и потребностей человека и улучшения его жизни.
5. На всем протяжении истории человечества люди изобретали инструменты, машины, материалы, технологии и изменяли окружающую среду.
6. Техника в более узком смысле означает промышленную технику, создавшую основу современного общества.
7. Современная техника началась с паровых машин, развития фабричной системы и массового производства товаров.

8. Научная революция, начавшаяся в XVI веке, вызвала появление новых идей, открытий и изобретений.
9. Только в XIX веке техника стала действительно основываться на работах ученых.
10. Первым действительно научно-техническим исследованием было исследование Фарадея.
11. История человеческого общества - это, в некотором смысле, - история развития науки и техники.

SCIENCE

Science is important to most people living in the modem world for a number of reasons. In particular, science is important to world peace and understanding, to the understanding of technology, and to our understanding of the world.

Science is important to world peace in many ways. On the one hand, scientists have helped to develop many of the modem tools of war. On the other hand, they have also helped to keep the peace through research which has improved life for people. Scientists have helped us to understand the problem of supplying the world with enough energy; they have begun to develop a number of solutions to the energy problem - for example, using energy from the sun and from the atom. Scientists have also analyzed the world's resources. We can begin to learn to share the resources with the knowledge provided to us by science. Science studies the Universe and how to use its possibilities for the benefit of men.

Science is also important to everyone who is affected by modern technology. Many of the things that make our lives easier and better are the results of advances in technology and, if the present patterns continue, technology will affect us even more in the future than it does now. In some cases, such as technology for taking salt out of ocean water, technology may be essential for our lives on Earth.

The study of science also provides people with an understanding of natural worlds. Scientists are learning to predict earthquakes, are continuing to study many other natural events such as storms. Scientists are also studying various aspects of human biology and the origin and developments of the human race. The study of the natural world may to help improve life for many people all over the world.

A basic knowledge of science is essential for everyone. It helps people to find their way in the changing world.

WORDS TO BE REMEMBERED

to be important to world peace and understanding	иметь большое значение для достижения мира и понимания (между народами)
to develop the modem tools of war	создать современное оружие
to keep the peace	сохранять мир
to improve life	улучшить жизнь
the problem of supplying the world with enough energy	проблема обеспечения мира энергией
to develop a number of solutions to the energy problem	разработать ряд решений энергетической проблемы
to analyzed the world's resources	анализировать мировые ресурсы
to share the resources	сообща пользоваться ресурсами
knowledge provided to someone	знания, предоставляемые
by science	кому-либо наукой
the Universe	Вселенная
to use possibilities for the benefit of men	использовать возможности на благо человека
to be affected by modem technology	быть связанным с современной техникой
a result of advances in technology	результат технических достижений

to be essential for our lives	иметь огромное значение для нашей жизни
to provide people with an understanding of	давать людям понимание
to predict earthquakes	предсказывать землетрясения
to study various aspects of human biology	изучать различные аспекты биологии человека
the origin and developments of the human race	происхождение и развитие человеческого рода
a basic knowledge of science	элементарное знание науки
to find one's way in the changing world	ориентироваться в меняющемся мире

Ex. 1. Answer the questions:

1. Why is science so important in the modem world?
2. How does science help to keep peace in the world?
3. How does science help to solve the energy program?
4. What proves that the study of science is important for understanding of the natural world?

Ex. 2. Translate into English

1. Наука помогла разработать современное оружие.
2. Наука находит все новые решения энергетической проблемы.

3. Наука помогла людям научиться использовать энергию солнца и атома.
4. Наука помогла научиться совместному использованию ресурсов.
5. Ученые предсказывают землетрясения.
6. Наука помогла улучшить жизнь людей.
7. Знания необходимы людям, чтобы ориентироваться в изменяющемся мире.

ENERGY

A body possesses energy when due to its position or condition it is capable of doing work and the work it can do is a measure of its energy.

Energy is of two forms: potential energy and kinetic energy. The potential energy of a body is the energy possessed by the body thanks, to its position or configuration. For example, a lifted weight has potential energy due to the higher position into which it has been lifted since it can do work as it falls under the action of gravity.

The potential energy of the weight in its highest position is the same as its kinetic energy after it has fallen to its, lowest position. We may say in general, that the energy possessed by an isolated body or a system of bodies is constant, that energy can neither be created nor destroyed and this fact is the principle of energy. The energy of a body may be measured in either of the two ways. First by the work which it is capable of doing. Second by the work, which has been done upon it to bring it into condition in which it possesses energy.

The potential energy of a lifted body with respect to a given level is expressed by the following equation

$$E = mgh$$

(E is equal to mg by h.)

or E is equal to mg multiplied by h, where E stands for the work done in lifting the body from the given level through a vertical height h against the force of gravity mg where m stands for mass and g for the acceleration of gravity. This expression is obtained by multiplying the weight of the body mg by the height through which it has been lifted.

The kinetic energy of a moving body may be expressed in terms of its mass m and its velocity V.

Let it be assumed that an unbalanced force F is applied to a free body of mass m at rest. Under the influence of the force F the body will start into uniformly accelerated motion, the acceleration being given p by a= E/ m (a is equal to F divided by m).

The velocity acquired by the body in t seconds is:

$$V = at$$

(V is equal to a multiplied by t.)

The work done by the force in speeding up the mass m to the velocity V is stored in the moving body as kinetic energy. It has been found that the kinetic energy of a body having a mass m and a velocity V is:

$$E = 1/2\ mV^2$$

(E is equal to a half of m multiplied by V squared or by V to the second power.)

If m is expressed in grams, V in m/sec, E gives kinetic energy in ergs. If m is expressed in pound and V in ft/sec, the kinetic energy is given in foot pounds.

WORDS TO BE REMEMBERED

to possess, possession, due to, to be capable of, to destroy, destruction, with respect to, level, to multiply, multiplication, to stand for, body, weight, velocity, to assume, assumption, rest (v, n), to acquire, to speed up, to be stored, squared, pound

Find The Equivalents:

the energy possessed	сила тяжести
a lifted weight	по отношению
an isolated system	энергия присущая
with respect to	данное тело
the given body	поднятый груз
uniformly accelerated motion	равномерно ускоренное движем

Ex. 1. a) Join suitable parts:

The potential energy of a body is the energy …

a) … done upon it to bring it into motion.

b) … lifted weight to the given level.

c) … possessed by the body thanks to its position.

d) … fallen under the action of gravity.

b) Find the answer to the following question:

What is the kinetic energy?

1. It is the energy processed by the body thanks to its position or configuration.

2. It is the energy converted from heat energy by means of machines.

3. It is the energy received by combusting coal or oil.

4. It is the energy of a moving body expressed in terms of its mass m and its velocity V.

Ex. 2. Insert prepositions where necessary:

1. For example, a lifted weight has potential energy … the higher position, into which it has been lifted. 2. A body can do work as it falls … the action … gravity. 3. The energy … a body may be measured … either … the two ways. First … the work which it is capable … doing. Second … the work which has been done … it. 4. E is equal … mg… h, where E stands … the work done … lifting the body. 5. F is equal … m multiplied … a.

Ex. 3. Translate from Russian into English:

1. Силы, действующие на тело, производят работу. 2. Тело, обладающее потенциальной энергией, может совершать работу. 3. Студент, читающий этот текст, учится в нашей группе. 4. Студенты, решающие это уравнение, со второго курса. 5. Кинетическая энергия, которой обладает тело, зависит от его массы. 6. Совершенная работа может быть измерена разными способами. 7. Измеряемое расстояние будет обозначено на схеме. 8. Используемое оборудование было получено в прошлом году. 9. Производимое оборудование широко используется на многих заводах. 10. Использованное оборудование оказалось очень хорошим. 11. Приложенная сила перевела

тело из состояния покоя в состояние движения. 12. Испытываемые материалы различались по своим свойствам. 13. Полученные результаты показали, что эта работа нужна. 14. Испытанные материалы требовали дальнейшей обработки.

Ex. 4. Translate from English into Russian:

Gravity is the most familiar of all natural forces but it is one that is often misunderstood. A box weighing 101 bs. will not fall any faster than one weighing 11 b. Both travel faster, the longer they fall. This is called acceleration. The rate of acceleration is the same for all falling objects. The speed of falling increases by 32 ft per second every second.

Gravity is not a power that belongs to the earth alone. Everything which has mass is attracted by and attracts other mass. The bigger and more dense the object is, the bigger its gravitational pull on other things. It is the pull of gravity that makes a pendulum return to its path. Gravity pulls the pendulum downwards, but due to its acceleration it overshoots the bottom point of its swing. Gravity then begins to work on it in the opposite direction eventually stopping it and causing it to swing back again and so to and so on.

Ex. 5. Read the text in 3 minutes without a dictionary and title it:

A lifted weight has potential energy due to the higher position into which it has been lifted since it can do work as it falls under the action of gravity.

Since energy may be transformed from potential to kinetic, a lifted weight which possesses potential energy in its highest position if allowed to fall will gradually lose its potential energy. At the same time it will acquire velocity and therefore kinetic energy. A ball thrown vertically into the air possesses at the beginning of its flight kinetic energy, but as it rises it gradually comes to rest thus losing its energy in that form. However as it rises it is acquiring potential energy with respect to the level from which it started. In other words while rising its kinetic energy is transformed into potential one. It is found that the total energy possessed by the body or system of bodies under consideration before and after the transformation is the same.

Ex. 6. Translate the following sentences:

1. They determined the speed of the body using a well-known formula. 2. The car speeded along the road. 3. The atoms speeded by a cyclotron impart their velocity to other atom. 4. Under the influence of the force F the body will start into

uniformly accelerated motion. 5. The force influences the body which starts moving. 6. No force of gravitation influences bodies in space. 7. A lifted weight has potential energy since it can do work as it falls under the action of gravity. 8. The scientists weighed the tested piece of metal and compared its weight with untested ones.

*Ex. 7. Solve the following problem*s:

1. What is the potential energy of a ball weighing 1 kg (0.5 kg; 2 kg) raised through 3 m (2 m, 5 m) vertically?
2. Calculate the kinetic energy of a bullet weighing 100 gr. and travelling at 350 ml sec.
3. What is the kinetic energy of a car travelling at 70 km/hour the mass of which is 2 tons?
4. Prove that the potential energy of a body which has fallen to the ground is equal to 0.

VARIETIES OF ENERGY

There exist many sources of energy in the world both potential and kinetic. One source consist of water falling from a high level such as an upland lake. Another source is wind or moving air. Others consist in tides in the sea, heat from subterranean sources and lastly coal deposits and oil wells yielding mineral oil.

But all these sources and stores of energy are not equally useful to mankind. Moreover some more stores of energy such as coal and oil can never be replaced by us when once used up. On the other hand stores of high level water are continually being replaced by rain and wind and tides will not, as far as we know, ever cease to exist. Hence a very important matter is the conversion of energy from one form to another. The form most required by us is mechanical rotational energy.

This energy is required to rotate shafts in a factory for driving various machines and also for driving the wheels of vehicles of automobiles or locomotives. The energy of water power is very unequally distributed, some countries such as Norway and Switzerland being rich in it and some such as England poor. England is rich in the potential energy of coal but has little or no oil wells.

Appliances for converting energy from one form to another are called engines. Thus a heat-engine is a machine for converting heat energy into mechanical energy of rotation by the combustion of coal or oil and a turbine or water engine can convert the kinetic energy of falling water into mechanical rotational energy.

The efficiency of an engine is the ratio of the energy delivered in the desired form to that given to the engine in the available form. Thus having given a heat-engine much energy by combusting coal or oil we take from it mechanical energy in kinetic form, rotational or motional.

Ex. 1. Point out which of these sentences contains the information from the text:

1. This science deals with the rates of reactions and the methods of accelerating them.
2. The potential energy of the weight in its highest position is the same as its kinetic energy after it has fallen to its lowest position.
3. All sources of energy are not equally useful to mankind, hence a very important matter is the conversion of energy from one form to another.

Ex. 2. Rearrange the sentences to make a summary of the text, use 'since ' (так как) where possible:

1. These sources of energy are not equally useful to mankind.

2. There exist many sources of energy in the world both potential and kinetic, such as wind, moving air or water falling from a high level.
3. The conversion of energy from one form to another is a very important matter as the form most required by us is mechanical rotational energy.
4. The ratio of the energy delivered in the desired form to that given to the engine is the efficiency of an engine.
5. Appliences for converting energy from one form to another are called engines.

CONSERVATION OF ENERGY AND MATTER

The Law of Conservation of energy means that no energy can be created or destroyed in any physical effects or transformations.

A similar generalization has long been recognized in chemical changes, viz., that there is no creation or destruction of mass. Thus in a closed vessel we may have chemical changes taking place but there is no alteration in the mass of the contents. Thus suppose in a glass bulb we have some water and some metal potassium and carefully weigh it. Then let the potassium be tilted into the water, a violent chemical action occurs producing hydrogen gas and also potassium hydroxide which dissolves in the rest of the water. But no change in the total weight of the contents of the bulb is observed. This truth is called the Law of Conservation of mass.

It has been shown however that matter can be converted into energy of radiation and that therefore the Law of Conservation of energy includes or implies also the conservation of mass.

Einstein has stated the rule for the equivalence of mass m in grams and energy *e* in ergs. It is $e=m\ (3x10^{10})^2$ or 1 gram=$9x10^{20}$ ergs. Where $3x10^{10}$ is the velocity of light in centimetres per second.

The fact that mass and energy can be changed into one another has given us means to explain the source of the energy radiated by the Sun for untold billions of years. It is from the melting away of the Sun's mass into radiation by degrees. The total energy radiated by the Sun as Light and Heat is $28x10^{26}x80\text{-}27x10^{6}=2248x10^{32}$ ergs per minute. To obtain the equivalent in mass we have to divide this last number by $9x10^{20}$ and we have $250x10^{12}$ grams or 250 million tons as the amount of mass of the Sun melting away per minute to maintain the Solar radiation.

No one needs be afraid we shall be left out in the cold for since I he mass of the Sun is 18 x 10^{26} tons the annual loss of mass is a mere insignificant fraction of the whole mass of the Sun.

Ex. 1. Find the wrong statement:

1. The law of Conservation of Energy includes or implies also the conservation of mass.
2. The fact that mass and energy can be changed into one another ex-plains the source of the energy radiated by the Sun.
3. The total energy radiated by the Sun is all radiated as Light.
4. The annual loss of the Sun's mass is a mere insignificant fraction of the whole mass of the Sun.

Ex. 2. Point out which sentence expresses the main idea of the text:

1. In a closed vessel a chemical reaction may take place but there is no alteration in the mass of the contents.
2. If potassium is put into water, a violent chemical reaction occurs.

3. his is called the Law of Conservation of mass.
4. No energy can be created or destroyed in any physical effects or transformations.

ELASTIC AND INELASTIC BODIES

Solid bodies offer resistance to a change in form or size. Certain substances when forcibly distorted exhibit the property of recovering; that is to say when the distorting force is removed they return more or less completely to the original form or size.

Bodies possessing the property of recovery are said to be elastic. Inelastic bodies do not possess this property. Elasticity is the property of a body to recover its original state. When acting upon an elastic body which changes its original form the external force is opposed by forces acting within a body. The internal force acting per unit of area is called the stress. The stress may be found as follows:

$$stress = \frac{external\ force}{area}$$

(That is, stress is equal to an external force divided by the area).

The distortion of a body per unit length or unit volume is called the strain.

$$strain = \frac{chainge\ in\ length}{original\ length}$$

(Strain is equal to a change in length divided by the original length).

There are three kinds of stress: tensile stress, hydrostatic stress and shearing stress.

A body is under tensile stress when the forces acting upon it tend to increase its length. The resulting change in length is called a stretch, and the strain in such a case is the ratio of the stretch to the original length of the body. A vertical wire is under tensile stress when supporting a weight.

A body is under hydrostatic stress when the pressure acting on it from all the sides is the same. For example, a small object in water is under hydrostatic stress since the water pressure acts upon it from all sides equally.

A body is under shearing stress when the forces acting upon it lend to cause one layer of particles in the body to move over an adjacent one. The strain in a body exceeding a certain value, the body will not recover completely its original state when the acting force is removed. A body strained beyond the elastic limit may not recover completely its original state when strained for a long time. Robert Hooke discovered that for elastic bodies under any kind of stress within the elastic limit, stress is proportional to strain. That is

$$\frac{stress}{strain} = const$$

This relation is known as Hooke's law. The elastic properties of various materials are different, the ratio of stress to strain being always the same for a given material within the elastic limit. The ratio of stress to strain for a given material is called the modulus of elasticity.

WORDS TO BE REMEMBERED

elasticity, elastic, to offer, to resist, resistance, force (v, n), size, to distort, distortion, to exhibit, property, to recover, recovery, to remove, complete, state (v, n), to oppose, within, internal, stress, external, volume, strain, tensile, shearing, stretch, ration, support (v, n), pressure, cause (v, n), adjacent, to exceed, beyond, to discover, discovery, various, differ, difference, different.

Find the equivalents:

the modulus of elasticity	скалывающее (срезывающее, касательное) напряжение
tensile stress	упругость

hydrostatic stress	отношение напряжения к деформации
shearing stress	растягивающее напряжение
elasticity	предел упругости
ratio of stress to strain	проявлять свойство
to exhibit the property	напряжение
stress	деформация
elastic limit	удлинение
strain	оказывать сопротивление
stretch	гидростатическое напряжение
to offer resistance	модуль упругости

Ex. 1. a) Find the correct answer to following, question:

1. When does the body recover its origin, al state?
2. Certain substances when forcibly distorted exhibit the property of recovery.
3. Bodies possessing the property of recovery are said to be elastic.
4. When the distorting force, does not exceed a certain limit bodies return more or less completely to their original form or size, the force being removed.

5. Elasticity is the property of a body to recover its original state.

b) Find the wrong statement:

1. The strain in a body exceeding a certain value, the body will mil recover completely its original state when the acting force is removed.
2. A body strained beyond the elastic limit for a long time always recovers completely its original form.
3. For elastic bodies under any kind of stress within the elastic limit stress is proportional to strain.

Ex. 2. Insert prepositions where necessary:

1. Inelastic bodies do not possess the property … recovering … their original form or state. 2. Solid bodies offer … resistance … a change … form or size. 3. A body is … tensile stress when the forces acting … it tend to increase its length. 4. The resulting change … length is called a stretch. 5. The strain … such a case is the ratio … the stretch … the original length … the body. 6. A body is … shearing stress when the forces acting … it tend to cause one layer … particles in the body to move … an adjacent one.

Ex. 3. Translate from Russian into English:

1. Тела, обладающие свойством восстанавливать свое первоначальное состояние, называются упругими. 2. Тело испытывает растягивающее напряжение, если силы, действующие на него, стремятся увеличить его длину. 3. Закон, выраженный этой формулой, очень важен. 4. Проведенный эксперимент показал, что данное тело испытывает скалывающее напряжение. 5. Падая, тело теряет потенциальную энергию. 6. Найдя модуль упругости, студент решил уравнение. 7. Зная эту величину, вы можете решить это уравнение. 8. Измерив совершенную работу, экспериментатор продолжил опыт. 9. Измеряя пройденный путь, студенты получили интересные результаты. 10. Превысив предел упругости, экспериментатор не смог продолжить опыт.

Ex. 4. Translate from English into Russian:

The word "strain" has been often used for the internal force in a body, or stress. It is present practice now to use the word "strain" as a synonym for deformation only. Thus the expression "stress and strain" is equivalent to the expression "stress and deformation". Owing to the conflicting meanings of the word "strain" it has been suggested that it should be avoided, the word "deformation" being used in its place.

Deformation may be of three kinds: elongation, or increase in length, due to tension; shortening, or decrease in length, due to compression; detrusion, or slipping of one plane on another, due to shear.

Ex. 5. Read the text in two minutes without a dictionary and answer the question "In place of what term is the term ‘stress’ used?"

Stress is the internal force which, when a body is subjected to external forces, tends to hold the molecules in their original relation and to preserve the integrity of the body. Stresses are measured by the same units as forces, namely, in pounds, tons, kilograms.

Unit stress is the measure of intensity of stress. It is the quotient obtained by dividing a total uniform stress by the number of units of area over which the stress is distributed. Unit stresses are expressed m pounds per square inch, tons per square foot, kilograms per square centimetre, and the like. Physicists usually use the term 'stress’ in place of 'unit stress’, and 'measure stress’ in pounds per square inch or kilograms per square centimetre. Confusion between the two uses of the term will be avoided if the units used are stated.

Ex. 6. Translate, the following sentences paving attention to the words in bold type:

1. The distorting force being removed, elastic bodies *recover* their original size. 2. You have been in the hospital for a month but now you have fully *recovered* and you needn't stay here any longer. 3. *Within* the elastic limit stress is proportional to strain. 4. Internal forces act *within* a body. 5. Don't exceed the speed of 60 km *within* the city limits. One should keep *within* this speed limits. 6. I'm in a great hurry, if he doesn't come within 5 minutes, I'll leave. 7. A body is under shearing stress when the forces acting upon it tend *to cause* one layer of particles in the body to move over an adjacent one. 8. Great changes *caused* by the discovery of the nuclear energy are taking, place in many branches of industry. 9. Peoples throughout the world are fighting for the *cause* of peace.

Ex. 7. Correct the following wrong statements in not less than 3 sentences:

1. Bodies possessing the property of recovery are called inelastic.

2. The distortion of a body per unit length or unit volume is called stress.
3. A body is under hydrostatic stress when the forces acting upon it tend to increase its length.
4. A body is under tensile stress when the forces acting upon it tend to cause one layer of particles in the body to move over an adjacent one.

ELASTIC AND INELASTIC BODIES
(part 2)

It may be assumed that a body consists of small particles, or molecules, between which forces are acting. These molecular forces resist the change in the form of the body which external forces tend to produce. If such external forces are applied to the body, its particles are displaced and the mutual displacements continue until equilibrium is established between the external and internal forces. It is said in such a case that the body is in a state of deformation or strain. During deformation the external forces acting upon the body do work, and this work is transformed completely or partially into the potential energy of strain. An example of such an accumulation of potential energy in a strained body is the case of a watch spring. If the forces which produced the deformation of the body are now gradually diminished, the body returns wholly or partly to its original shape and during this reversed deformation and potential energy of strain, accumulated in the body, may be recovered in the form of external work.

The property of bodies of returning, after unloading, to their initial form is called elasticity. It is said that the body is perfectly elastic if it recovers its original shape completely after unloading; it is partially elastic if the deformation, produced by the external forces, does not disappear completely after unloading. In the case of a perfectly elastic body, the work done by the external forces during deformation will be completely transformed into the potential energy of strain. In the case of a partially elastic body, part of the work done by the external forces during deformation will be dissipated in the form of heat which will be developed in the body during the non-elastic tie formation, experiments show that such structural materials as steel, wood, and stone may he considered as perfectly elastic within certain limits which depend upon the properties of the material. Assuming that the external forces acting upon the structure are known, it is a fundamental problem for the designer to establish such proportions of (he members of the structure that it will improve the condition of a perfectly elastic body under all service conditions. Only under such conditions will there be continued reliable service from the structure and no permanent set in its members.

Ex. 1. Read the text and find the English equivalent to the following Russian sentence:

Только при таких условиях конструкция будет долго и надежно служить, и в строительных элементах не будет остаточной деформации.

Ex. 2. Point out which of these sentences contains the information from the text:

1. There are three kinds of stress: tensile stress, hydrostatic stress and shearing stress.
2. A heat engine is a machine for transforming heat into mechanical energy.
3. The body is perfectly elastic if it recovers its original shape completely after unloading; it is partially elastic if the deformation, produced by the external forces, does not disappear completely after unloading.

Ex. 3. Point out which of the sentences express the main idea of the text:

1. An example of an accumulation of potential energy in a strained body is the case of a watch spring.
2. Experiments show that such structural materials as steel, wood and stone may be considered as perfectly elastic.
3. These molecular forces resist the change in the form of the body which external forces tend to produce.
4. The body is perfectly elastic if it recovers its original shape completely after unloading.
5. The property of bodies of returning, after unloading, to their initial form is called elasticity.

ELECTRIC POWER CONSUMERS AND POWER SYSTEMS

An electric power consumer is an enterprise utilizing electric power. Its operating characteristics vary during the hours of day, days and nights, days of week and seasons.

All electric power consumers are divided into groups with common load characteristics. To the first group belong municipal consumers with a predominant lighting load: dwelling houses, hospitals, theatres, street lighting systems, mines, etc.

To the second group belong industrial consumers with a predominant power load (electric motors): industrial plants, mines, etc.

To the third group belongs transport, for example, electrified railways. The fourth consists of agricultural consumers, for example, elec-trotractors.

The operating load conditions of each group are determined by the load graph. The load graph shows the consumption of power during different periods of day, month, and year. On the load graph the lime of the maximum loads and minimum loads is given.

Large industrial areas with cities are supplied from electric networks fed by electric power plants. These plants are interconnected for operation in parallel and located in different parts of the given area. They may include some large thermal and hydroelectric power plants.

The sum total of the electric power plants, the networks that interconnect them and the power utilizing devices of the consumers, is nailed a power system. All the components of a power system are interrelated by the common processes of protection, distribution, and consumption of both electric and heat power.

In a power system, all the parallelly operating plants carry the total load of all the consumers supplied by the given system.

The building up of a power system is of great importance for the national economy. An economical utilization of the power plant installations and of the sources of power is achieved by interconnected operation of a series of power plants in a common power distribution system.

Ex.l. Answer these questions:

1. What enterprises are called electric power consumers?
2. When do their operating characteristics vary?
3. What consumers belong to the four different groups?
4. What conditions does the load graph determine?
5. What type of system is called a power system?
6. What processes interconnect the components of a power system?
7. In what way is an economical utilization of power installation! achieved?

RESISTORS

A resistor is one of the most common elements of any circuit. Resistors are used:

1. to reduce the value of current in the circuit;

2. to produce IxR voltage drop and in this way to change the value of the voltage.

When current is passing through a resistor its temperature rises high. The higher the value of current the higher is the temperature of a resistor. Each resistor has a maximum temperature to which it may be heated without a trouble. If the temperature rises higher the resistor gets open and opens the circuit.

Resistors are rated in watts. The watt is the rate at which electric energy is supplied when a current of one ampere is passing at a potential difference of one volt. A resistor is rated as a 1-W resistor if its resistance equals 1,000,000 ohms and its current-carrying capacity equals 1/1,000,000 amp, since P = ExI = IRxI = J^2R where P - power is given in watts, R - resistance is given in ohms and I - current is given in amperes.

If a resistor has a resistance of only 2 ohms but its current-carrying capacity equals 2,000 amp, it is rated as a 8,000,000-W resistor.

Some resistors have a constant value - these are fixed resistors, the value of other resistors may be varied - these are variable resistors.

Ex.l. Complete the sentences using the correct variant

1. A resistor is used …
   a) to measure the resistance.
   b) to reduce the current.
   c) to change the resistance.
   d) to produce IxR voltage drop.
2. When current passes through a resistor …
   a) its temperature drops.
   b) its temperature rises.
3. Resistors are rated …
   a) in ohms.
   b) in volts.
   c) in watts.
4. Power is given …
   a) in amperes.
   b) in watts.
5. Fixed resistors have …
   a) a constant value.
   b) a variable value.
6. The value of a variable resistor …
   a) is fixed.

b) is varied.

7. A two-ohm resistor rated as a resistor 8,000,000-W …

a) has a current-carrying capacity equal to 2,000 amp.

b) has a current-carrying capacity equal to 200 amp.

8. The higher the value of current, of a resistor …

a) the lower is tire temperature

b) the higher is the temperature of a resistor.

Ex. 2. Pair work. Put these questions to your group mate and let him/her answer them.

1. What is a resistor used for?
2. When does the temperature of a resistor rise?
3. What element is used to change the value of voltage?
4. How are resistors rated?
5. What types of resistors do you know?
6. When does a resistor get open?
7. What does an open resistor result in?
8. What is the difference between a fixed resistor and a variable resistor?
9. How much is the current-carrying capacity of a two-ohm resistor?
10. What resistors have a variable value?

Ex. 3. Solve the problem:

What is the maximum current for a resistor having a 5-watt capacity and a resistance of 20,000 ohms?

SERIES CIRCUIT AND PARALLEL CIRCUIT

Compare circuits a and b. Circuit a consists of a voltage source and two resistors. The resistors are connected in series. Circuit a is a series circuit. Circuit b consists of a voltage source and two resistors. The resistors are connected in parallel. Circuit b is a parallel circuit.

A parallel circuit has the main line and parallel branches. In circuit b the value of voltage in R_1 equals the value of voltage in R_2.The value of voltage is the same in all the elements of a parallel circuit while the value of current is different. A parallel circuit is used in order to have the same value of voltage.

In circuit a the value of current in R_1 equals the value of current in R_2. The value of current is the same in all the elements of a series circuit while the value of voltage is different. A series circuit is used in order to have the same value of current. In R_1, $V_1=IR_1$ is the voltage drop in R_1. In R_2 the voltage equals IR_2, IR_2 is the voltage drop in R_2. In circuit *c* a trouble in one element results in no current in the whole circuit. In circuit *d* a trouble in one branch results in no current in that branch only, a trouble in the main line results in no current in the whole circuit.

Ex.l. Complete the sentences using 'while'. Follow the model:

Model: Resistors connected ***in series*** have the same value **of current…** Resistors connected ***in series*** have the same value of current while resistors connected ***in parallel*** have the same value ***of voltage***.

1. Resistors connected ***in series*** have ***different*** values of voltage while …
2. A trouble in one element of a ***series*** circuit results in no current in the ***whole circuit*** while …
3. In order to have the same value ***of current*** in all the elements, a ***series*** circuit is used while …
4. No current in a ***parallel*** circuit results from a trouble in the ***main line*** while …

Ex. 2. Answer the following questions:

1. What type of circuit has the main line and parallel branches?

2. What type of circuit is used in order to have the same value of current in all the elements?
3. What type of circuit is used in order to have the same value of voltage in all the elements?
4. What does a trouble in the main line result in?
5. What does a trouble in a branch result in?
6. What does no current in a series circuit result from?
7. How much does the sum of I*R voltage drops equal?
8. What is the difference between series and parallel circuits?

CAPACITORS

A capacitor is one of the main elements of a circuit. It is used to store electric energy. A capacitor stores electric energy provided that a voltage source is applied to it.

The main parts of a capacitor are metal plates and insulators. The function of insulators is to isolate the metal plates and in this way to prevent a short.

In the diagram one can see two common types of capacitors in use nowadays: a fixed capacitor and a variable one. The plates of a fixed capacitor cannot be moved; for this reason its capacity does not change. The plates of a variable capacitor move; its capacity changes. The greater the distance between the plates, the less is the capacity of a capacitor. Variable capacitors are commonly used by radiomen; their function is to vary the frequency in the circuit. Fixed capacitors are used in telephone and radio work.

Fixed capacitors have insulators produced of paper, ceramics and other materials; variable capacitors have air insulators. Paper capacitors are commonly used in radio and electronics; their advantage is their high capacity: it may be higher than 1,000 picofarad.

Besides, electrolyte capacitors are highly in use. They also have a very high capacity: it varies from 0.5 to 2,000 microfarad. Their disadvantage is that they change their capacity when the temperature changes. They can operate without a change only at temperatures not lower than - 40°C.

Common troubles in capacitors are an open and a short. A capacitor stops operating and does not store energy in case it has a trouble. A capacitor with a trouble should be substituted by a new one.

Ex.l. Complete these sentences using the correct variant:

1. A capacitor is used …
   a) to supply voltage

b) to increase the voltage output.

c) to store energy.

2. The main parts of a capacitor are ...

a) insulators only.

b) metal plates only.

c) metal plates and insulators between them.

3. The function of insulators is ...

a) to store energy.

b) to isolate the metal plates.

c) to prevent a short between the metal plates.

4. The capacity of a capacitor depends on ...

a) the size of the plates.

b) the distance between the plates.

c) the material of the insulators.

5. The capacity of a fixed capacitor ...

a) is constant.

b) is varied.

6. The plates of a variable capacitor ...

a) can be moved.

b) cannot be moved.

7. In order to charge a capacitor a voltage source is applied .

a) to the metal plates.

b) to the insulators.

8. The greater the distance between the plates ...

a) the greater is the capacity of a capacitor.

b) the less is the capacity,

9. Variable capacitors have ...

a) air insulators.

b) paper insulators.

c) ceramic insulators.

10. Electrolyte capacitors have ...

a) a very low capacity.

b) a very high capacity.

11. In case a capacitor has a trouble ...

a) it operates.

b) it stops operating.

Ex. 2. Pair work. Put these questions to your group mate and ask him/her to answer them.

1. What is a capacitor used for?
2. What are the main parts of a capacitor?
3. What is the function of insulators?
4. What does the capacity of a capacitor depend on?

5. What is the difference between a fixed capacitor and a variable one?
6. What should be done in order to change a capacitor?
7. What is the relation between the value of capacity and the distance of plates?
8. What type of insulators have variable capacitors?
9. What should be done in case a capacitor has a trouble?

Ex.3. Solve these problems:

Draw a diagram of a circuit consisting of two resistors and two capacitors connected in parallel. A battery of four cells is applied to the circuit. Two ammeters are used: one is connected to the main line, the other - to a parallel branch. What is the function of each dement? In what way can one increase the value of resistance in the circuit?

Suppose one of the branches stops operating. What does it result from?

THERMODYNAMICS

Thermodynamics is that branch of physics, which deals with the conversion of mechanical energy into thermal energy and the reverse process of transforming heat into work.

The production of heat by mechanical means may be illustrated by-the phenomena of friction. For example, fire may be started while rubbing together two sticks of wood. Heat is developed-when compressing a gas. The transformation of heat into work may be illustrated by operation of a steam or gas engine by means of which heat may be transformed into mechanical energy.

So a heat engine is a machine for transforming heat into mechanical energy, the most important of the practical heat engines being the steam engine and the internal combustion engines.

To transform energy from any of its numerous forms into heat is a comparatively simple process. To transform heat into work is a different matter. Experience shows that any actual physical process, as the change of state of a system, is irreversible and is accompanied by frictional effect. A strictly reversible frictionless process being an ideal, it may be approached but never attain. In the case of the ideal reversible process, there is no change in the quantity of available energy; but an actual irreversible process is always accompanied by a decrease of the amount of energy available for transformation. All transformations of energy are subject to two far-reaching laws:

1) The general law of conservation of energy, of which the following is a statement: the total energy of an isolated system remains constant and cannot be increased or diminished by any physical process whatever.

2) The law of degradation of energy. According to this law, the result of any transformation of energy is the reduction of the quantity of energy that may be usefully transformed into mechanical work.

The first law of thermodynamics is merely the law of conservation applied to the transformation of heat into work. It may be stated as follows: when work is expended in producing heat the quantity of heat generated is equivalent to the work done; and conversely, when heat is employed to do work, a quantity of heat precisely equivalent to the work done disappears.

The second law of thermodynamics is essentially the law of degradation of energy. Whereas the first law gives a relation that must be satisfied in any transformation of energy, it is the second law that gives information regarding the possibility of transformation and the availability of a given form of energy for transformation into work. A general statement of the second law is: ‘No change in a system of bodies that takes place of itself can increase the available energy of the system’.

WORDS TO BE REMEMBERED

branch, to deal with, to convert, conversion, reverse, heat, phenomenon (pl. -na), friction, frictional, to rub, wood, to compress, compression, steam (n, a), engine, importance, important, combustion, numerous, to compare, comparison, comparatively, simple, experience, to accompany, to attain, quantity, decrease (v, n), to reach, statement, to diminish, to reduce, reduction, to expend, expenditure, to generate, generation, to empty, employment, precision, precise, to disappear

Find the equivalents:

phenomenon of friction	обратный процесс
steam engine	обратимый процесс
reverse process	первый и второй закон термодинамики
irreversible process	идеальный процесс, в котором отсутствует трение
reversible process	явление трения
quantity of heat generate	необратимый процесс
available energy of the system	любой действительный физический процесс
change of state of the system	имеющаяся энергия системы
ideal frictionless process	любое преобразование, любое превращение энергии из одной формы в другую

any actual physical process	изменение состояния системы
any transformation of energy	двигатель внутреннего сгорания
internal combustion engine	паровой двигатель
first and second laws of thermodynamics	количество полученной теплоты

Ex. 1. a.) Join suitable parts:

1. A heat engine is …
   a) … a machine for transforming heat into mechanical energy.
   b) … a machine for defining the amount of mechanical energy.
   c) … a machine for solving physical problems.
   d) … a machine for producing sound waves.
2. The production of heat by mechanical means may be illustrated by…
   a) … the phenomena of elasticity when elastic bodies recover their original state, the acting force removed.
   b) … the phenomena of potential energy of a body which it possesses due to its position.

c) … the phenomenon of conservation of energy which can neither be created nor destroyed in any physical effects.

d) … the phenomenon of friction.

b) Find the wrong statement:

1. Fire may be started rubbing together two sticks of wood.
2. The transformation of heat into work may be illustrated by operation of a steam or gas engine.
3. To transform energy from any of its form into heat is impossible.
4. A strictly reversible frictionless process being an ideal, it can never be attained.

Ex. 2. Insert prepositions where necessary:

1. Thermodynamics deals … the conversion … mechanical energy … thermal energy. 2. The production … heat … mechanical means may be illustrated … the phenomenon … friction. 3. A heat engine is a machine … transforming heat … mechanical energy. 4. To transform energy … any … its numerous forms … heat is a comparatively simple process. 5. … the case … the ideal reversible process, there is no change … the quantity … available energy. 6. No

change … a system … bodies that takes place … itself can increase the available energy … the system.

Ex. 3. Translate from Russian into English using the Absolute Participle Construction:

1. Выполненная работа может быть вычислена по данному уравнению, а потери не рассматриваются. 2. Теплота может быть превращена в работу и обратно, причем отношение теплоты к работе является постоянным. 3. Тело не восстанавливает свою первоначальную форму, если напряжение превышает определенную величину. 4. После того как были получены новые данные, испытываемые материалы были отправлены на завод. 5. Так как работа была очень трудная, студенты не смогли ее выполнить. 6. Так как студент не знал этого закона термодинамики, преподаватель поставил ему плохую оценку.

Ex. 4. Translate from English into Russian:

Definition of International Temperature Seale

1. The thermodynamic Centigrade Scale, on which the temperature of melting ice and the temperature of condensing water vapour, both being under the pressure of one standard atmosphere, are numbered 0° and 100° respectively, is

recognized as the fundamental scale, all temperature measurements being ultimately referable to it.

2. The experimental difficulties of the practical realization of the thermodynamic scale being great, a practical scale designed as the International Temperature Scale was adopted. This scale conforms with the thermodynamic scale as closely as is possible with present knowledge.

Ex. 5. Translate the following sentences paving attention to the words in bold type:

1. This branch of chemistry ***deals*** with organic compounds. 2. This newspaper article ***deals*** with the events in Africa. 3. This girl doesn't want to help anybody, she doesn't listen to anybody, she is very difficult to ***deal*** with. 4. To learn so many words at once is not a simple matter 5. All ***matter*** is composed of a limited number of elements. 6. I'm sorry, I've left your book at home. — It doesn't ***matter***, bring it to me tomorrow. 7. I'll be at home all the evening and I'll help you ***no matter*** when you come. 8. Why are you crying? What's the ***matter***? 9. In the ***case*** of the ideal reversible process, there is no change in the quantity of available energy. 10. The doctor said that I his patient's ***case*** was very serious. 11. In ***case*** this article

is referred to we shall consider it. 12. He is a criminal and his ***case*** will be brought to court.

HEAT ENERGY

The mechanical theory of heat states that heat is a form of energy due to the motion or configuration of the molecules of a body. Like mechanical energy, heat energy may be of the kinetic or of the potential form. The expression Σ [sigma]=1/2 mv^2 extended to the moving molecules of a system gives the thermal kinetic energy of the system. The kinetic theory of gases shows that the temperature of a body is a measure of its thermal kinetic energy. The temperature rising, the thermal kinetic energy is increased. The temperature falling, the thermal kinetic energy is decreased. Thermal potential energy is due to the position or configuration of the molecules of a body. Thus the volume of the body being increased, work is required to separate the molecules against their mutual attractions, and this work is stored as potential energy. Again, the state of aggregate being changed, as in fusion or vaporisation, work is required to break down the molecular structure, and this work is stored in the system as potential energy. In the case of gases, like air and nitrogen, the attractive forces between the molecules are so small that the thermal potential energy is practically zero. The internal energy of a gas is therefore assumed to be wholly of the kinetic form.

While dealing with energy the conventional units are:

1) for mechanical energy, the foot-pound (ft.-lb.) and the horse" power-hour (hp.-hr.), which is equal to 1,980,000 ft-Ib.;

2) for heat energy, the British thermal unit (B.t.u.), which is de-fined as the heat required to raise the temperature of one pound of water from 63° to 64°F.

3) for mechanical of heat

1 B.t.u. =777.64 ft.-lb.

1 hp.-hr.=2546.2 B.t.u.

This numerical relation between the unit of heat and the unit of work has been determined very accurately from experiments.

Ex. 1. Read the text and find the English equivalents to the following Russian sentences:

1. Если температура тела поднимается, его тепловая кинетическая энергия увеличивается. 2. Когда температура падает, тепловая кинетическая энергия тела уменьшается. 3. Таким образом, если объем тела

увеличивается … . 4. … если (когда) агрегатное состояние изменяется … .

Ex. 2. Point out which sentence expresses the main idea of the text

1. The numerical relation between the unit of heat and the unit of work has been determined very accurately from experiments.
2. While dealing with mechanical energy the conventional units are — the foot-pound (ft.-lb.) and the horsepower-hour (hp.-hr.).
3. Heat, being a form of energy, may be of the kinetic or of the potential form.

A THERMODYNAMIC SYSTEM

A thermodynamic system is defined as a body or group of bodies capable of receiving and giving out heat or other forms of energy. Examples of such systems are the media used in heat engines, as water vapour, air, ammonia, etc. In order that a system may receive or give out energy, its state must change; hence the magnitudes that determine I he state must change. It is assumed ordinarily that the system is homogeneous and of uniform density and temperature throughout, also that it is subjected to uniform pressure. Then the magnitudes describing the state of a unit mass are: the pressure p, the temperature t, and (lie volume v. In the case of a homogeneous mixture of vapour and liquid, as wet steam, a fourth variable is required; this is the ration x of the weight of vapour to the weight of the mixtures. These magnitudes, p, v, t and x are called the coordinates of the system.

Many of the equations of thermodynamics are simplified by taking the temperatures from absolute zero instead of from the zero of the F or C scale. The position of the absolute zero, as determined by experiments on actual gases, is about 273.1° below zero C, or 459.6° below zero F. Hence, denoting ordinary temperatures by t and absolute temperatures by T

$$T=t+273.1 \text{ for the C scale}$$

$$T=f+459.6 \text{ for the F scale}$$

Of the three coordinates, p, v, T any two may be, in general, taken as independent and the third is then a function of these two. Thus in case of a confined gas, the pressure p may be kept at any desired value and by the addition of heat the temperature T may be raised to any predetermined point. The volume v must depend upon the values given to p and T; that is, v is a function of p and T, as v=f(p, T)

Ex. 1. Point out which of these sentences contains the information from the text

1. The most important of the practical heat engines are the steam engines and the internal combustion engines.
2. The mechanical theory of heat states that heat is a form of energy due to the motion or configuration of the molecules of a body.
3. In order that a system may receive or give out energy, its state must change.
4. The magnitudes p, v, t and x are called the coordinates of the system.

APPLIED MECHANICS

Mechanics is that branch of physical science which considers the effect of forces upon the motion or upon the conditions of material bodies.

Applied mechanics is a part of mechanics. It includes the laws of mechanics to be applied to the motions of particles and of rigid bodies as used in problems of engineering. The condition of rest is considered to be the limiting condition of motion.

It is assumed to classify a rigid body as a collection of material particles the distances between which are known not to be changed.

A particle is a body or a part of a body the dimensions of which are so small as to be negligible when compared with its surroundings or with its range of motion, so that the force acting upon it may be considered to be localized at a point.

The subject of applied mechanics may be divided into two ports, statics and dynamics, and dynamics may be further divided into kinematics and kinetics. It is statics that treats bodies in equilibrium, mid dynamics that treats the particles and bodies in motion. Kinematics is the part of dynamics to treat the motion of particles and rigid bodies without reference to the forces that produce or change the motion. Kinetics is the part of dynamics to treat the motions of material bodies as caused or changed by the application of forces. The limiting case of bodies with constant velocity and therefore in equilibrium is sometimes treated in kinetics as well as in statics.

In order to understand thoroughly such a subject as applied mechanics, it is necessary for the student to solve a number of problems. Л problem in mechanics consists of a statement of certain known quantities and relations from which certain other unknown quantities or relations are to be determined.

There are three common methods of analysis of problems: the graphic method, the trigonometric method and the algebraic one. In (he graphic method, the quantities are to be represented by corresponding lines or areas; the relations between them are to be represented by the relations of the parts of the diagram.

In the trigonometric method, the quantities are to be represented by lines or areas as well but they are not necessarily drawn to scale. In the algebraic method, quantities are represented by symbols; the relations between them are shown by signs indicating the operations; and the solution of the resulting equations is made by algebra.

WORDS TO RE REMEMBERED

applied mechanics, to move, motion, rigid, particle, dimensions, to surround, surroundings, range (v, n), without, to solve, solution, certain, common, to correspond, correspondence, corresponding, scale, sign.

Find Russian equivalents to the following:

applied mechanics	твердое тело
a rigid body	Постоянный
negligible	Размеры
constant	теоретическая механика
dimensions	Допускать
quantity	Незначительный
scale	Величина
to assume	масштаб, размер

Ex. 1. a) Find the correct answer to the following question:

What problems does applied mechanics deal with?

1. It deals with the problems of the bodies in cosmic space.
2. It deals with the law of mechanics applied to the motions of particles and of rigid bodies as used in problems of engineering.
3. It deals with the questions of transformation of heat energy into mechanical one.

4. It deals with the questions of transformation of particle energy during their motion.

b) Join suitable parts:

1. Mechanics is that branch of physical science which considers …
   a) … the effect of radiation upon people and animals.
   b) … the effect of forces upon upon motion or upon the conditions of material bodies.
   c) … the forms of transformation of energy connected with the movement of material systems under the action of force factors.
2. It is assumed to classify a rigid body as …
   a) … a collection of particles the distances between which are known to be always changing.
   b) … a collection of material particles; the mass of them is known not to be changed during the motion.
   c) … a collection of material particles the distances between which are known not to be changed.
3. … the quantities are represented by corresponding lines or areas and the relations between them are represented by the relations of lire parts of the diagram.

a) In the algebraic method …

b) In the graphic method …

c) In the trigonometric method …

c) Find the definition of 'kinematics':

1. It is the part of dynamics to treat the motions of material bodies as caused or changed by the application of forces.
2. It is the part of dynamics to treat the motion of particles and rigid bodies without reference to the forces that produce or change the motion.
3. It is the science to study the laws of interaction of particles during the motion.

d) Find the adequate translation of the English sentence:

A rigid body is known to be a system of particles that always have a fixed relation to each other.

1. Твердое тело всегда было известно как система частиц, имеющих определенное отношение друг к другу.
2. Твердое тело принимается за известную систему частиц, которые всегда имеют определенное отношение друг к другу.

3. Известно, что твердое тело представляет собой систему частиц, всегда имеющих определенное отношение друг к другу.

Ex. 2. Insert prepositions where necessary:

1. Applied mechanics may be divided … two parts statics and dynamics. 2. Statics treats … bodies … equilibrium. 3. A problem … mechanics consists … a statement … certain known quantities and relations … which certain other unknown quantities are to be determined. 4. In the trigonometric method, the quantities are to be represented … lines or areas. 5. Understanding … applied mechanics depends … the ability … students to solve a number … problems.

Ex. 3. Translate from Russian into English:

1. Вопрос, который нужно обсудить на этом собрании, очень важен. 2. Никого нет, кто бы мог помочь ему. 3. Нам не о чем разговаривать. 4. Статика это наука, которая рассматривает равновесие тел. 5. Чтобы определить это отношение, нужно было решить уравнение. 6. Вы должны присутствовать на собрании, которое состоится десятого февраля. 5. Ученые считают, что результаты, которые должны быть получены в этом эксперименте, будут широко использованы. 8. Уравнение, которое нужно решить, написано на доске. 9. Преподаватель

принес статью, которую нужно перевести. 10. В этой статье есть кое-что, что следовало бы обсудить.

Ex. 4. Translate from English into Russian:

‘***Work***’ — When the point of application of a force moves, so that the force has a component along the displacement of its application point the force is said to do work. If the force is assumed to be constant in magnitude and in direction and the displacement to be straight, then to determine the magnitude of the work one should multiply the component of the force along the displacement, and the displacement; if this component is in the direction of the displacement, the work is regarded as positive; if opposite, the work is negative. The unit of work depends on the units used for force and distance.

Ex. 5. Read the text in two minutes without a dictionary and render it in Russian; give Russian terms for 'rectilinear motion' and 'curvilinear motion

The two kinds of motion most commonly considered are rectilinear motion and curvilinear motion. As the term implies, rectilinear motion of a particle is motion along a straight line. Curvilinear motion is motion along a curved path.

If a particle has rectilinear motion with respect to some point which is assumed to be fixed, its displacement is its total change of position during any given interval of time.

Displacement is independent of the path traversed and depends only upon the initial and final position of the particle. It is a vector quantity and is represented graphically by a vector.

Answer the following questions:

1. What is rectilinear motion?
2. What is curvilinear motion?
3. What is displacement of a particle and what does it depend on?

Ex. 6. Translate the following sentences from English into Russian paving attention to the word in bold type.

1. Statics ***treats*** bodies in equilibrium. 2. I don't like the way he ***treats*** his son. 3. He had ***a rest*** in the Crimea last year. 4. When a body is ***at rest*** the sum of the force applied is zero. 5. It ***rests*** with you to decide. 6. Some students have come, ***the rest*** of them are still having their exams. 7. ***Common*** people all over the world are .fighting for peace. 8. They are friends, they like to read, they go in for sports together, in general they have much ***in common***. 9. There are three

common methods of solving these problems.

Ex. 7. Correct the following wrong statements in not less than 3 sentences:

1. In graphic method quantities are represented by symbols: the relations between them are shown by signs indicating the operations.
2. The algebraic method representing quantities by the corresponding lines or areas is the only method to solve a problem in applied mechanics.
3. Kinematics which is the part of statics treats the motion of material bodies as caused by the application of forces.

Ex. 8. a) Find the resultant of the two parallel forces, acting vertically both downward:

F_1=10kg(15kg)

F_2=5kg(10kg)

b) Find the resultant of the two parallel forces, one (F_1) acting vertically downwards, the other (F_2) - vertically upward:

F_1=12kg(15kg)

F_2=9kg(7kg)

THE MOTION OF RIGID BODIES

A rigid body is a system of particles that always have a fixed relation to each other.

The motion of a rigid body is said to be rectilinear translation if the motion of each particle of the body is along a straight line and parallel to the line of motion of each of the other particles of the body. The motion of any particle of the body is considered to represent the motion of the entire rigid body. The entire rigid body may be treated as a particle having the same position and motion as the center of gravity of the body.

The motion of the body of a railway car along a straight track or the motion of a hammer of a pile driver are all examples of rectilinear translation.

In general, any particle of a body considered free has a system of forces acting upon it. Some of them may be considered external to the body as a whole, and some of which are internal. The resultant of all these forces for the particle is called the effective force for the particle and is equal to d M a, d M being the mass of the particle and a its acceleration. If the particles of the body were all made free of each other, and each had its effective force acting, the motion of the system of particles would be the asme as the actual motion of the body.

The resultant of all these effective forces for all the particles of the body is called the resultant effective force of the body.

Since the internal forces between the particles of a rigid body are always mutual, that is, equal and opposite, their total resultant for the whole body is assumed to be equal to zero. It follows, then, that the resultant effective force for all the particles of a rigid body must be equivalent to the resultant of the external forces.

Since each particle has a force equivalent to $\partial M \times a$ acting upon it, and since each force is proportional to the mass of the particle, the point of application of the resultant is necessarily the same as that of a system of particles acted upon by their own weights.

A COUPLE OF FORCES

Two parallel forces, equal in amount, opposite in direction, and with different lines of action are known to constitute a couple.

No single force can balance a couple. Since the resultant (R) of I lie couple is zero, the resultant of the couple and another force cannot be zero.

A couple may be transferred to any plane parallel to its original plane without change of effect. Since the moment of a couple with respect to any point 0 in its plane is the same as its moment with respect to an axis through 0, perpendicular to its plane, the moment is independent of the location of the plane of the couple along the axis.

Since couples are known to have no properties but magnitude and direction, they may be represented graphically by vectors. The length of the vector represents to some scale the magnitude of the couple and the direction of the vector shows the direction of its plane and the direction of its rotation. The vector is drawn perpendicular to I lie plane of the couple. The conception commonly used with regard to the arrow is that, if the couple is viewed from the head end of the vector, the rotation of the couple appears positive.

The position of the vector is immaterial, since the moment of the couple is the same with respect to any axis perpendicular to its plane. The moment of the resultant of any member of coplanar couples or of couples in parallel planes is equal to the algebraic sum of the moments of the component couples.

It is possible to compound couples combining their vectors. Since the position of the vector is immaterial, the vectors of the couples may all be taken through any given point, then added graphically. The resultant vector represents completely the resultant couple.

WORDS TO BE REMEMBERED

couple, opposite, single, since, to transfer, transference, magnitude, arrow, view (v, n), to appear, appearance, member, coplanar, possibility, possible, compound (u, a), to add, addition, additional

Ex. 1. a) Find Russian equivalents to the following:

Coplanar	пара сил
to transfer	Ось
to represent	Результирующая
Resultant	единственный
Single	представлять
Axis	перемещать
Couple	расположенный в одной плоскости

b) Find English equivalents to the following

Плоскость	rotation
Вращение	property

Свойство	plane
Первоначальный	quantity
Составлять	to constitute
Величина	original

Ex. 2. a) Join suitable parts:

1. The moment of the resultant of any member of coplanar couples is equal to …
   a) … the algebraic sum of the moments of the component couples.
   b) … the resultant vector which is represented graphically.
   c) … the trigonometric function of the moments of the component couples.
2. The direction of the vector is known to show …
   a) … -the direction of the resultant of the couple which is al-ways equal to zero.
   b) … the direction of its plane and the direction of its rotation.
   c) … the direction of two parallel forces with different lines of action.

3. The parallel forces, equal in amount, opposite in direction and with different lines of action are known …
   a) … which constitute a couple.
   b) … that will constitute a couple.
   c) … to constitute a couple.
4. No single force is known …
   a) … that will balance a couple.
   b) … to balance a couple.
   c) … that have balanced a couple.
5. The resultant of the couple appears …
   a) … will be equal to zero.
   b) … was equal to zero.
   c) … to be equal to zero
6. This science seems
   a) … that which is rather difficult.
   b) … is difficult
   c) … to be difficult

b) Find the definition of the term 'couple':

1. A couple may be transferred to any plane parallel to its original plane without change of effect.
2. Since the resultant of the couple is zero, the resultant of the couple and another force cannot be zero.

3. Since couples are known to have no properties but magnitude and direction, they may be represented graphically by vectors.
4. It is two parallel forces, equal in amount, opposite in direction, and with different lines of action.

Ex. 3. Insert prepositions where necessary:

1. A couple may be transferred … any plane parallel … its original plane … change… effect. 2. The moment … a couple is the same … respect … any point O … its plane as its moment … respect … any axis through O, perpendicular to its plane. 3. It is quite possible to understand applied mechanics … means … solving a number of problems. 4. The moment is independent … the location … the plane … the couple … the axis.

Ex. 4. Translate from Russian into English:

1. Известно, что твердое тело — система частиц, связанных друг с другом. 2. По-видимому, одна сила не уравновешивает пиру сил. 3. Известно, что результирующий вектор полностью представляет результирующую пару сил. 4. Известно, что пары сил графически выражаются векторами. 5. Принимается, что сила прилагается в любой точке по линии ее воздействия. 6.

Ожидают, что эта проблема будет решена в ближайшем будущем. 7. Сообщают, что последние опыты привели к интересным открытиям. 8. Полагают, что этот ученый работает над данной проблемой уже много лет.

Ex. 5. Translate the following from English into Russian:

The moment of a force with respect to a line is known to be the product of its rectangular components perpendicular to the line (the other being parallel) and the distance between the line and the perpendicular component (or the force); the line is the "axis" of moments. Moments of forces about the same axis are commonly given signs, those corresponding to the forces which tend to turn the body acted upon about the axis in the same direction (clockwise) being given the same sign and others the opposite. To compute the moment of a force with respect to an axis, one should resolve the force into three rectangular components, one being parallel to the axis, the other two perpendicular to it; then the moment of the given force is stated lo equal the algebraic sum of the moments of the two perpendicular components.

Ex. 6. Read this text in one minute without a dictionary and answer the question 'What is the angular acceleration?'

Rotation of a body is motion such that one straight line in the body or in its extension remains fixed. This line is the axis of rotation and all points of the body not on the line describe circles. All lines of the body perpendicular to the axis describe equal angles in equal times.

The angular acceleration of a rotating body is the rate at which its angular velocity is changing. The angular acceleration of a rotating body depends only on the moments of all the external forces acting on the body about the axis of rotation and the moment of inertia of the body whose centers are on the line.

Ex. 7. Translate the following sentences paying attention to the words in bold type:

1. If a force is parallel to the axis of moments or if it cuts the axis, then its moment ***with respect*** to the axis is zero. 2. Carbon and oxygen differ ***in many respects***. 3. The "arm" of the force ***with respect*** to the point is the distance between the force and the point. 4. All children must love and ***respect*** their parents. 5. The total stress in any cross-section must be equal to the ***resultant*** of the external forces to produce equilibrium. 6. World War II ***resulted*** in formation of several socialist states. 7. This experiment ***resulted*** in the discovery of several new properties of this mineral. 8. The ***results*** of their work are

known to have been used in our industry. 9. Such an experiment usually ***results*** in obtaining new information.

Ex. 8. Correct the following wrong statements in not less than 3 sentences:

1. It is quite possible for a single force to balance a couple because they are equal in amount.
2. The length of the vector represents only the direction of rotation.
3. Since couples have many properties they are known to be represented by vectors.
4. The moment of the resultant of any member of coplanar couples is equal to zero.

COUPLES

Two equal, parallel and opposite forces are called a couple, the perpendicular distance between the forces is the "arm" of the couple. The moment or torque of a couple with respect to any point or origin in their plane is the algebraic sum of the moments of the two forces with respect to that point. The sum or moment, the same for all origins in the plane, always equals the product of one of the forces and the arm of the couple. Moments of the couples whose planes are parallel are sometimes given signs; those corresponding to couples which tend to turn the body in the same direction are given the same sign, and the others the opposite sign. A couple may be represented sufficiently for statical purposes by means of a single vector; the vector is drawn perpendicular to the plane of the couple, and the arrowhead is so placed that it points toward the place from which the rotation appears, say counter-clockwise.

Two couples whose vectors are equal—the same in length and direction—have equal moments (sign included) and their planes coincide or are parallel. Such are equivalent couples; that is, either may be substituted for the other without change of effect on the body acted upon if rigid. The resultant of a number of couples is a couple. If the planes of the given couples are parallel or coincident, the resultant couple is one whose plane is parallel to the others and whose moment (with sign) equals the algebraic sum of the moments of the given couples. If the planes of the given couples are not parallel or coincident, then the resultant can be determined from tire vectors representing the different couples; thus, add the vectors, that is, find their resultant; this resultant vector represents the resultant couple.

To resolve a couple into component couples it is necessary to resolve the vector of the given couple into component vectors which are perpendicular to the planes of the desired components; these component vectors represent the several component couples.

Ex. 1. Find the definition of the term 'equivalent couples':

1. It is one whose plane is parallel to the others and whose moment (with sign) equals the algebraic sum of the moments of the given couples.
2. Two equal, parallel and opposite forces are called a couple.
3. It is two couples whose vectors have equal moments (sign included) and whose planes coincide or are parallel.

Ex. 2. Point out which of these sentences contains the information from the text

1. Two or more forces which together are equivalent to a given force are components of the force.
2. The process of determining components of a force is called resolution.
3. Two couples whose vectors are equal—the same in length and direction—have equal moments.

4. The distance between the force and the point is the arm of the force with respect to the point.

FORCE

An action of one body upon another which changes or tends to change the state of rest or motion of the body acted upon, is called force. A force has magnitude, direction, and place of application; when the extent of l he place of application is negligible and the force is regarded as applied or concentrated at a point, this is the point of application, and a line through Die point parallel to the direction of the force is the line of action. The word "sense" as applied to forces refers to one of the two directions along the line. Any number of forces considered collectively is a system of forces; a system is concurrent or nonconcurrent, according as the lines of action of the forces do or do not intersect in a point, and it is coplanar, or noncoplanar, according as they do or do not lie in a plane. The resultant of a system of forces is the single force which is equivalent to that system, but if a system has no single force equivalent, then the simplest equivalent system may be called the resultant, a resultant never includes more than two forces. The process of determining the resultant is called composition.

Ex. 1. Find the definition of the term 'resultant':

1. It is any number of forces considered collectively.
2. A resultant never includes more than two forces.
3. It is the single force which is equivalent to the system of forces.

STATIC AND KINETIC FRICTION

If a block rests upon a horizontal supporting surface, the weight of the block and the resistance of the surface are the two forces acting upon the block. If these distributed forces are considered to be acting at the center of the area of contact, they may be represented by W and N (Fig. a). If a small horizontal force P is applied to the block, and it is still at rest, the force to balance P is the resistance of the supporting plane parallel to P, tangential to the surface, as shown in Fig. (b). This resistance is called friction and is denoted by F.

If the force P is increased gradually, it will reach a certain value that the friction F can no longer balance, and the block will move. While the block is at rest, the friction is called static friction. The highest value of the static friction, that when motion is just impending, is called the limiting friction and will be denoted by F’. After motion begins, the friction decreases and is called kinetic friction, or friction of motion. If the block is moving or tending to move over a supporting surface, the friction of the supporting surface is known to be opposite to the direction of the motion.

Adhesion should not be confused with friction. Adhesion is the attraction between two surfaces in contact. It depends upon the areas in contact and is independent of the pressure. Friction is independent of the areas and varies as the pressure. For nearly all problems in engineering, adhesion may be neglected.

If the two surfaces in contact are hard and well polished, the frictional resistance becomes very small but never reaches zero. If the friction could reach zero, the surface would be the ideal smooth surface, for which the resistance would be normal to the surface of contact. In some problems in engineering, friction is very small compared with other forces acting and may be neglected in the solution without appreciable error.

WORDS TO BE REMEMBERED

to distribute, distribution, figure (fig.), to denote, gradually, to impede, adhesion, to confuse, confusion, to attract, attraction, attractive, to depend, dependence, hard (a, adv), hardly, smooth, normal to, to appreciate, appreciable.

Ex. 1. Find the equivalents:

supporting surface	значение
resistance	сцепление
distributed forces	опорная поверхность
value	движение
motion	трение
adhesion	сопротивление
friction	распределенные силы

Ex. 2. a) Join suitable parts:

1. After motion begins …
   a) … the forces of adhesion do not act any longer.
   b) … the force of friction changes its direction.
   c) … the friction decreases and is called kinetic friction or friction of motion.
2. The frictional resistance becomes very small …
   a) … if the two surfaces in contact are hard and well polished.
   b) … if the two surfaces in contact are rough.
   c) … if the speed of motion increases.

b) Find the wrong statement:

1. If the block is moving or tending to move over a supporting surface, the friction of the supporting surface is known to be opposite to the direction of the motion.
2. If the block is moving or tending to move over a supporting surface, the friction decreases with the increase of speed.
3. If the block is moving over a supporting surface, the frictional resistance is called static friction.

c) Find the definition of the notion 'static friction'

1. It is one of the distributed forces acting upon the block which tests upon a horizontal supporting surface.
2. It is the attraction between two surfaces in contact.
3. It depends upon the area in contact and is independent of the pressure.
4. It is the resistance of the surface while the block is at rest.

Ex. 3. Insert prepositions where necessary:

1. Friction is independent … the areas. 2. Adhesion depends … the areas … contact. 3. Sometimes … engineering

problems friction is very small compared … other forces acting … body. 4. … the solution … such problems friction may be neglected … great error. 5. If the block is moving … a supporting surface, the friction … the supporting surface is opposite … the direction … the motion. 6. Adhesion is the attraction … two surfaces … contact. 7. While the block is … rest, the friction is called static friction.

Ex. 4. Translate from Russian into Enslish:

1. Сообщают, что эти проблемы решат в недалеком будущем. 2. Известно, что такие опыты проводятся часто. 3. Известно, что ученые уже решили эту проблему. 4. Говорят, что статья уже переведена. 5. На конференции сообщили, что эти проблемы уже решены. 6. Ожидают, что делегация прибудет завтра. 7. Говорят, что студенты уже сдали этот экзамен. 8. По-видимому, этот студент сейчас занимается в читальном зале. 9. По-видимому, она уже прочла этот текст. 10. Кажется, они сейчас работают в лаборатории. 11. Кажется, он уже решил это уравнение. 12. Сообщают, что делегация приехала в понедельник. 13. Они обсуждают проблемы, которые надо решить. 14. Определите силу, которую можно приложить в точке В. 15. Чтобы изучить теоретическую механику, вы

должны много заниматься. 16. Может быть этот вопрос сейчас решается. 17. Мой друг, должно быть, определил это вещество 18. Не может быть, чтобы он это сделал. 19. Неужели он это сделал?

Ex. 5. Translate from English into Russian:

Without friction the locomotive's driving wheel is known to spin uselessly. The thrust of the wheel is to be equalled by the amount of friction between it and the rail if it is to move along without spinning. The friction will be increased if the down ward pressure on the rail is increased. As a result locomotives are designed so that the axle loading of the driving wheels is to provide friction that equals their power and trailing bodies are loaded as little as possible.

Ex 6. Read the text in one minute without a dictionary and render it in Russian:

The laws of friction for lubricated surfaces are different from those for dry surfaces. The laws of friction for dry surfaces were received from experimental studies and may be stated as follows:

1. Friction varies directly as the normal pressure.
2. Limiting static friction is slightly greater than kinetic friction.

3. Ordinary changes of temperature affect friction only slightly.
4. At slow speeds friction is independent of the speed. At high speeds, friction decreases as the speed increases.
5. Kinetic friction decreases with the time.
6. Friction is increased by a reversal of motion.

Ex. 7. Translate the following sentences paying attention to the words in bold type:

1. I have not seen him ***since*** summer. 2. ***Since*** they know the material well enough we can expect them to pass their exam. 3. He has been working at this problem ***since*** he came to Moscow. 4. The friction of the ***supporting*** surface is opposite to the direction of the motion. 5. Five columns ***support*** this part of the building. 6. After his father's death he had to work to ***support*** the family. 7. The ***solution*** of this problem depends on the theoretical knowledge. 8. Many chemical substances exist in ***solutions***. 9. These wife and husband seem to be a very good couple. 10. The resultant of the couple and another force cannot be zero for the resultant of the ***couple*** is zero. 11.They have been studying this material ***for*** the whole term. 12. It is necessary to know this method ***for*** solving a number of problems.

Ex. 8. Correct the following wrong statements in not less than 3 sentences:

1. Adhesion is dependent of the pressure.
2. When the two surfaces in contact are badly polished and soft the frictional resistance very easily reaches zero.
3. In solution of engineering problems friction is very important because it is great compared with the other forces which may be neglected.

Ex. 9. Solve the following problem:

It needs a horizontal force of 25 kg to move a box weighing 75 kg across a floor. What force should be required to push back this empty box weighing 7 kg (10 kg)?

RECTILINEAR VELOCITY AND SPEED

The velocity of a particle with rectilinear motion is the time rate of its displacement from some assumed point of reference. If the particle traverses equal spaces in equal time intervals, its velocity is uniform, and the amount of its velocity is equal to the ratio of the given displacement to the time in which the displacement was made. If s is the displacement and t the time, the amount of the velocity v is given by the equation

$$v = \frac{s}{t}$$

If the unit of displacement is the foot, and the unit of time is the second, the unit of velocity will be the foot per second, abbreviated ft. /sec. If the unit of displacement is the mile, and the unit of time is the hour, the unit of velocity will be the mile per hour, abbreviated m.p.h.

If a particle moves over unequal spaces in equal time intervals, its velocity is variable. In this case the ratio of any given space s to the time t in which it was traversed gives only the average velocity. As the space s is shortened until it becomes ds, and the time in which as is traversed becomes at, this average velocity approaches the value of the instantaneous velocity at the point where ds is taken. This instantaneous velocity is

$$v = \frac{ds}{dt}$$

Velocity has direction as well as magnitude. It is therefore a vector quantity and is represented graphically by a vector. Speed is the scalar, or quantity, part of velocity and is merely the rate of travel, irrespective of direction. The units of speed are the same as the units of velocity.

Ex. 1. Point out which of these sentences contains the information from the text:

1. Applied mechanics deals with the problems connected with the motion of particles or rigid bodies.
2. The velocity of a particle has direction as well as magnitude and therefore it may be considered to be a vector quantity and is represented graphically by a vector.
3. Two forces that constitute a couple can't be balanced by a single force.

Ex. 2. Rearrange the sentences to make a summary of the text, use 'since ' where possible:

1. If a particle moves over unequal spaces in equal time intervals, its velocity is variable.
2. If a particle traverses equal spaces in equal time intervals, its velocity is uniform.
3. Speed is irrespective of direction.
4. Velocity has direction as well as magnitude.
5. Velocity is represented graphically by a vector.
6. Speed is a scalar.
7. The text deals with velocity and speed.

ELECTROMAGNETIC RELAY

Electromagnetic devices called relays are widely used in various branches of industry.

The main parts of a relay are an electromagnet, a spring and an armature. When a current starts flowing in the electromagnet winding, the armature moves and the spring closes the contacts. The primary circuit of a relay is its electromagnet circuit and the secondary circuit is the one closed by the contacts.

When there is no current in the relay's primary circuit, the spring pulls the armature and the contacts open.

Fig. shows how a relay is used to control the work of an electric motor. The relay is placed close to the motor which is connected to its secondary circuit. The armature closes the contacts of the secondary circuit, and the motor starts operating; it will stop when the relay opens.

Without a relay, conductors with a large cross-section would have to be brought to the motor. This would be very uneconomical. The current a relay is tens and even thousands of times smaller than that used to power the motor. Therefore, the connecting wires can have small cross-sections. In many systems the relay primary circuit operates automatically. Every evening and morning street lights are switched on and off from the main control panel by means of a great number of relays.

Ex.l. Complete the sentences using the correct variant:

1. The main parts of a relay are …
   a) an electromagnet, a capacitor, and a spring.
   b) an electromagnet, an armature, and a spring.
2. When current starts flowing …
   a) the spring opens the contacts.
   b) the spring closes the contacts.
3. The spring pulls the armature …
   a) when there is current in the primary circuit.
   b) when there is no current in the primary circuit.
4. Tire wires connecting the panel with the relay …
   a) have a large cross-section.
   b) have a small cross-section.
5. Street lights are switched on and off …
   a) by means of relays
   b) by means of electric motors.

Ex.2. Complete these sentences using ‘while’

1. The primary circuit of a relay is its electromagnetic circuit … … .

2. When there is no current in the relay's primary circuit the contacts open …
3. Without a relay conductors with a large cross-section should be used
4. Every evening street lights are switched on …

Ex. 3. Answer the following questions:

1. What are the main parts of a relay?
2. How is a relay put into operation?
3. When does the spring pull the armature?
4. What wires connect the panel with the relay?
5. By what means are street lights switched on and off?

INDUCTANCE AND MUTUAL INDUCTANCE

Any conductor has some definite value of inductance. The inductance of a conductor shows how well it can provide induced voltage.

Elements of a circuit with a definite value of inductance are coils of wire called *inductors*. The inductance of a coil depends upon its size and material. The greater the number of turns of a coil, the higher is its inductance. An iron core also increases the value of inductance. Coils of this type are used for low-frequency currents while coils with an air core are used for high-frequency currents. Two coils A and B are brought close together and a source of varying current is applied to coil A. If a measuring device is connected across the terminals of coil B it will be found that a voltage is induced in this coil though the two coils do not touch. The secondary voltage, that is the voltage in coil B, is called induced voltage and energy from one coil to the other transfers by induction. The coil across which the current is applied is called the primary, that in which voltage is induced is called the secondary. The primary and the secondary coils have mutual inductance. Mutual inductance is measured in the same units as inductance, that is in henries.

Thus, when a rate of change of one ampere per second in the primary coil will produce one volt in the secondary coil, the two coils have one henry of mutual inductance. It should be taken into consideration that induction by a varying current results from the change in current not in the current value. The faster the current changes, the higher the induced voltage.

Ex.l. Complete the sentences using the correct variant:

1. Any conductor has …
   a) some definite value of resistance.
   b) some definite value of inductance.

2. Any conductor can provide …

   a) electric power.

   b) induced voltage.

3. Elements with a definite value of inductance …

   a) are called inductors.

   b) are called coils.

   c) are called sources.

4. The inductance of a coil depends upon …

   a) its size.

   b) its core.

   c) its material.

   d) its number of turns.

5. An iron core …

   a) increases the value of inductance.

   b) decreases the value of inductance.

6. The value of mutual inductance is measured …

   a) in watts.

   b) in henries.

7. Induction by a varying current …

   a) results from the change in current.

   b) results from the change in the current value.

8. The faster the current changes …
   a) the lower is the induced voltage.
   b) the higher is the induced voltage.

Ex. 2. Answer the following questions:

1. What value of inductance do conductors have?
2. What is the function of inductors?
3. What are elements with a definite value of inductance called?
4. What does the inductance of a coil depend upon?
5. How does the inductance of a coil depend upon the material of its core?
6. In what units is the value of mutual inductance measured?
7. What does induction by a varying current result from?
8. What is the relation between the current changes and the value of induced voltage?
9. What is the unit of resistance?
10. What is the unit of potential difference?
11. For what type of current is an air core used?
12. What is the relation between the number of turns of a coil and its inductance value?

TRANSFORMERS

A transformer is used to transfer energy. Due to the transformer electric power may be transferred at a high voltage and reduced at the point where it must be used to any value. Besides, a transformer is used to change the voltage and current value in a circuit.

A two-winding transformer consists of a closed core and two coils (windings). The primary winding is connected to the voltage source. It receives energy. The secondary winding is connected to the load resistance and supplies energy to the load.

The value of voltage across the secondary terminal depends on the number of turns in it. In case it is equal to the number of turns in the primary winding the voltage in the secondary winding is the same as in the primary.

In case the secondary has more turns than the primary the output voltage is greater than the input voltage. The voltage in the secondary is greater than the voltage in the primary by as many times as the number of turns in the secondary is greater than the number of turns in the primary. A transformer of this type increases or steps up the voltage and is called a step-up transformer. In case the secondary has fewer turns than the primary the output voltage is lower than the input. Such a transformer decreases or steps down the voltage, it is called a step-down transformer.

Compare Tl and T2 in the diagram. T1 has an iron core. For this reason it is used for low-frequency currents. T2 has an air core and is used for high frequencies.

Common troubles in transformers are an open in the winding, a short between the primary and the secondary, and a short between turns. In case a transformer has a trouble it stops operating or operates badly. A transformer with a trouble should be substituted.

Ex.l. Complete the sentences using the correct variant:

1. A transformer is used …
   a) to store charge.
   b) to prevent the change of energy.
   c) to transfer energy.
   d) to change the voltage and current value in a circuit.
2. Electric power is transferred at a high voltage and reduced to any value …
   a) due to resistors.
   b) due to capacitors.
   c) due to transformers.

3. A transformer consists of …
   a) cores only.
   b) the primary and the secondary windings.
   c) a core and the primary and the secondary windings.
4. The function of the primary is …
   a) to prevent the change of voltage.
   b) to supply energy.
   c) to receive energy.
5. The function of the secondary is …
   a) to receive energy.
   b) to supply energy.
   c) to transfer energy.
   d) to decrease the value of charge.
6. A step-up transformer is used …
   a) to step down or decrease the secondary voltage
   b) to step up or increase the primary voltage.
7. A step-down transformer is used …
   a) to step down the secondary voltage.
   b) to step down the primary voltage.
8. A transformer with an iron core …
   a) is used for high-frequency currents.
   b) is used for low-frequency currents.

9. A transformer with an air core is used …
   a) for high-frequency currents and for low-frequency currents
   b) for high-frequency currents only.
10. In a step-up transformer …
   a) the number of turns of the secondary winding is greater than the number of turns of the primary.
   b) the number of turns of the primary winding is greater than the number of turns of the secondary.
11. A transformer should be substituted …
   a) in case it has an open in the winding.
   b) in case it has a short between the primary and the secondary.
   c) in case it has a short between turns.

Ex.2. Pair work. Put these questions to your group mate and ask him/her to answer them.

1. What is a transformer used for?
2. What does a transformer consist of?
3. What is the function of the primary winding?
4. What is the function of the secondary winding?

5. What type of transformer is called a step-up transformer?
6. What type of transformer is used for high-frequency currents?
7. What type of transformer is called a step-down transformer?
8. What type of transformer is used for low-frequency currents?
9. What is the relation between the number of turns in the windings and the value of current?
10. What are common troubles in a transformer?
11. What should be done in case a transformer has a trouble?

BETA RAYS

Beta rays are made up of particles. These rays are bent by a magnetic field in such a way as to reveal a negative charge on the particles. They would not be bent if they had no charge, that is if they were electrically neutral. In weight and charge they are alike to the particles of the cathode ray. They are electrons. Electrons have very little weight. They may travel at great speeds, varying from 62,000 to 180,000 miles per sec. (i.e. at their fastest they approach the speed of light).

Fast electrons may have sufficient energy to penetrate the surrounding electron orbits of an atom. They are then deflected from their original course by the positive charge of the nucleus. Were the nucleus electrically neutral, the electrons would not be deflected from their original course. They are more often turned through larger angles than is the case for alpha-particles, since they have a much smaller mass. Slower electrons are more easily deflected, and in consequence more quickly lose their energy. If electrons pass a gas, they will ionize it. They are able to penetrate l/8th in of aluminium or 2 mm of lead.

When a narrow cathode ray beam is passed through thin metal foil the rays act like X-rays (as if they were not particles but a radiation) and are diffracted giving an appropriate pattern on a fluorescenl screen. This means that beams of electrons can act as if they were made up of waves of definite wavelength as is the case for light. Cathode rays are also found to cast shadows of objects in their path. This shows how difficult it is to distinguish usefully between particles and radiation — the latter itself measured as photons or quantum ‘packages’. When (as a cathode ray) they are stopped by any solid object, they set up X-rays (an analogy would be machine-gun bullets striking a target and producing sound waves).

Each particle does not produce scintillation on a zinc sulphide screen, but the beam as a whole does produce scintillation. When travelling slowly electrons are easily absorbed by atoms, even by those of gases.

WORDS TO BE REMEMBERED

ray, to bend, field, way, to reveal, charge (v, n), to be alike, to travel, mile, light, sufficient, to penetrate, to deflect, deflection, angle, angular, case, in case, to lose, foil, appropriate, pattern, screen, beam, wave, shadow, path, to distinguish, the latter, gun, bullet, target

Ex. I. Find the equivalents:

Radioactive substances	большие углы
positive charge	катодный луч
the cathode ray	скорость света
the speed of light	Светящийся экран
the original course	Радиоактивные вещества
larger angles	Положительно заряженные частицы
fluorescent screen	Первоначальное направление

Ex. 2. a) Find the definition of the notion 'beta rays':

1. These rays are streams of particles, they are a form of radiation unaffected by a magnetic or electric field.
2. These rays are a form of radiation made up of negatively charged particles, having very little weight, which may travel at great speeds.
3. These rays are a form of radiation made up of positively charged particles bent by a magnetic field.

b) Find the wrong statement:

1. The speed of electrons is not constant, it varies from 62,000 to 180,000 miles per sec., i.e. at their fastest it approaches the speed of light.
2. Elections have very little weight and may travel at great speeds sometimes approaching the speed of light.
3. Electrons have very little weight and may travel at great speeds due to the fact they are electrically neutral.

c) Join suitable parts:

1. Beta rays would not be bent by a magnetic field if …
   a) … they didn't travel at a speed approaching the speed of light.
   b) … they were not a sort of radiation.
   c) … they could not penetrate metals.
   d) … they were electrically neutral.

2. If electrons pass a gas …,
   a) … they will ionize it.
   b) … they will act like X-rays (have considerable penetrating power).
   c) … they will travel at a speed approaching the speed of light.
3. If fast electrons had not sufficient energy …,
   a) … they will not penetrate the surrounding electron orbits of an atom.
   b) … they would not penetrate the surrounding electron orbits of an atom.

Ex. 3. Insert prepositions or adverbs where necessary:

1. Beta rays are made up … particles. 2. Gamma rays are unaffected … a magnetic or electric fields. 3. X-rays are not deflected … electric or magnetic fields. 4. Electrons may travel … great speeds. 5. If beta rays move … their approach speed, they approach the speed … light. 6. The speed of electrons from 62,000 to 180,000 miles … sec. 7. Fast electrons are deflected … their original course … the positive charge … the nucleus. When a narrow cathode ray beam is passed … thin metal foil the rays act … X-rays.

Ex. 4. Translate from Russian into English:

1. Бета-лучи не отклонялись бы в магнитном поле, если бы они не имели отрицательного заряда. 2. Альфа-лучи не отклонялись бы в электрическом поле, если они были электрически нейтральны. 3. Если бы эти две силы не были параллельны, они не составили бы пару. 4. Если бы не было света, поды, кислорода, то на земле не было бы жизни. 5. Спутники двигались бы по прямой, если бы на них не действовала сила притяжения. 6. Если мы будем работать над этой проблемой, мы сможем найти ответ на многие вопросы. 7. Сила притяжения будет уменьшаться, если расстояние от земли будет увеличиваться.

Ex. 5. Translate from English into Russian:

Cosmic rays are an extremely hard, penetrating radiation, i.e. of shorter wavelength than gamma rays. These rays penetrate thick lead plates that would absorb gamma rays, though some parts of this very variable radiation would be absorbed by 10 cm. of lead. They are thought to enter the earth's atmosphere from outer space. In the earth's atmosphere the primary rays are largely converted into secondary rays of less energy such as positrons, highspeed electrons, etc. The intensity of cosmic radiation diminishes between the equator and the poles. This is believed to be due to the deflection by the earth's magnetic field. If there were no earth's magnetic field, the intensity of cosmic radiation would not depend on the width.

Ex. 6. Read this text in 1 minute without a dictionary and answer the Question 'What rays are described here’:

These rays are a form of radiation. They are not streams of particles. They are more penetrating than X-rays, to which they are akin. They will pass through it. of iron or many inches of lead. They are only surpassed for penetrating by cosmic rays. They ionize a gas through which they pass since they "knock out" some of the planetary electrons of the gas atoms, which electrons in their turn produce more ions from other atoms. These rays cause a diffuse fluorescent screen to glow. They are unaffected by a magnetic or electric field.

Ex. 7. Translate the following sentences paying attention to the words in hold type:

1. I was in Moscow in I960. When I came to Moscow in 1970 it had greatly changed since. 2. Since an atom is electrically neutral, it must have an equal number of positive and negative charges. 3. Since ancient times people dreamed of conquering space. 4. His dream is to work as an engineer somewhere in the

Far East. 5. He can't answer this question as he doesn't know the subject well. 6. This instrument is as precise as possible. 7. As far as we know the supplies of oil will last not more than a few centuries. 8. What reaction is going on? 9. What was being discussed when you came? 10. What do you call this substance? 11. It is necessary for him to measure the distance. 12. Fermat and Descartes did much for the development of analytic geometry. 13. These mathematicians worked at this problem for a long time. 14. This discovery is very important for it has opened vast prospects before our science.

Ex. 8. Correct the following wrong statements in not less than 3 sentences:

1. Beta rays are bent by a magnetic field in such a way as to reveal a positive charge on the particle.
2. Electrons are electrically neutral and they may travel at low speed.
3. Fast electrons have little penetrating power and are seldom deflected from their original course.

RADIOACTIVITY

It was found that the property of emitting penetrating radiations is not confined to uranium and its compounds. These, strange happenings attracted the attention of Marie Curie (1867—1934), the wife of a well-known French scientist Pierre Curie (1859—1906). She thought that the radioactivity inside uranium was caused by some other chemical element. She obtained large quantities of pitchblende and after much patient work she produced a very small amount (a few milligrams) of a mysterious element. This substance gave out a bluish glow at the bottom of a test tube, and because it shone like this, the Curies called it "radium". It was found to be a million times more radioactive than uranium, but gave out alpha, beta and gamma

radiations like uranium. The Curies and other scientists discovered that since beta particles were fast electrons, and since they were much smaller than atoms, the atoms inside radium were breaking up.

For a time the discovery of radium overshadowed the importance of uranium. Later careful studies of uranium were made and these showed that there was a whole family of radioactive elements. Gradually it was found that uranium itself was very unsettled and unstable. Its atoms had too much energy inside them and this extra energy was released in the form of radioactivity. The alchemists of the middle ages had dreamed of turning or transmitting elements from one to another especially base metals into gold. Had the alchemists known this property of uranium, they might have tried to turn metals into gold. Little did they know that uranium was turning by natural radioactivity into a whole family of other elements.

In uranium there are a number of elements, each breaking down by natural radioactivity into elements of smaller weight. During 4,500 million years half the atoms in uranium change into uranium XI atoms by ejecting subatomic particles. Again uranium XI gives out beta radiation, and half its atoms change into uranium X2 in the course of 24 days. Uranium X2 breaks up into another element and this goes on until radium is formed. Radium breaks up and there are further atomic transmutations until finally natural radioactivity stops and lead is formed. Thus there is a whole series of changes going on in uranium and the changes stop with lead. The first change from uranium to uranium XI takes longest. When an atom of radium gives out a radioactive ray it loses a tiny bit of weight. The lost weight, which has been measured, appears as energy. If an atom of radium did not lose weight, no energy would appear. The discovery that radioactive atoms generate energy as they give off rays helped to start the science of nuclear energy.

Ex. 1. Point out the sentence (or the sentences) which contains the information from the text:

1. Radioactive substances emit three different types of radiations— beta, gamma and alpha rays.
2. Beta particles are fast electrons.
3. There are many radioactive elements.

Ex. 2. Rearrange the sentences to make a summary of the text:

1. It gave out alpha, beta and gamma rays.
2. Marie Curie discovered a mysterious element which she later called "radium".
3. Later it was proved that radioactive atoms released extra energy in the form of radioactivity.
4. The new element was found to be radioactive.
5. The important discovery helped to start the science of nuclear energy.

X-RAYS

Have you ever thought about the time when there was no radio, when flying was a dream, and cinema was only one year old? It was the time when the first motor-cars had just appeared.

It was in a world such as this that in 1895 a German professor Wilhelm Konrad

Roentgen discovered a new kind of invisible rays. These rays could pass through clothes, skin and flesh - and cast the shadow of the bones themselves on a photographic plate. You can imagine the impression this announcement produced at that time.

Let us see how Roentgen came to discover these all-penetrating rays. One day Roentgen was working in his laboratory with a Crookes tube. Crookes had discovered that if he put two electric wires in a glass lube, pumped air out of it and connected the wires to opposite electric poks, n stream of electric particles would emerge out of the cathode (that is, the negative electric pole).

Roentgen was interested in the fact that these cathode rays made certain chemicals glow in the dark. On this particular day Roentgen was working in his darkened laboratory. He put his Crooks' tube in a box made of thin black cardboard and switched on the current to the tube. The black box was lightproof, but Roentgen noticed a strange glow at the far comer of his laboratory bench. He drew back the curtains of his laboratory window and found that the glow had come from a small screen which was lying at the far end of the bench.

Roentgen knew that the cathode rays could make the screen glow. But he also knew that cathode rays could not penetrate the box. If the effect was not due to the cathode rays, what mysterious new rays were causing it? He did not know, so he called them X-rays.

Roentgen placed all sorts of opaque materials between the source of his X-rays and the screen. He found that these rays passed through wood, thin sheets of aluminium, the flesh of his own hand; but they were completely stopped by thin lead plates and partially stopped by the bones of his hand. Testing their effect on photographic plate he found that they were darkened on exposure to X- rays.

Roentgen was sure that this discovery would contribute much for the benefit of science. Indeed, medicine was quick to realize the importance of Roentgen's discovery. The X-rays are increasingly used in industry as well.

WORDS TO BE REMEMBERED

X-rays	Рентгеновские лучи
to discover a new kind of	Открыть новый тип

invisible rays	невидимых лучей
pass through clothes, skin	Проникать сквозь одежду,
and flesh	кожу и тело
to cast the shadow of … on a photographic plate	Отбрасывать тень … на фотографической пластинке
to produce an impression	Произвести впечатление
to discover all-penetrating rays	Открыть всепроникающие лучи
a Crookes tube	трубка Крука
an electric wire	Электрический провод
electric poles	электрические полюса
a stream of electric particles	поток электрических частиц
the cathode	Катод
to make certain chemicals glow	вызывать свечение некоторых материалов
black cardboard	черный картон
to switch on the current to	подключить ток к
lightproof	Светонепроницаемый
a screen	Экран
to penetrate the box	проникать сквозь коробку

to cause smth.	вызывать что-либо
opaque materials	Непрозрачные материалы
the source of X-rays	источник рентгеновских лучей
lead plates	свинцовые пластины
to test an effect on	проверить воздействие на
to be darkened on exposure	темнеть при попадании
to X- rays	рентгеновских лучей
to contribute much for the	внести большой вклад в
benefit of science	науку
to be quick to realize	быстро обнаружить
to be increasingly used	все шире использоваться

<u>Ex l. Answer the questions:</u>

1. How can the time of Roentgen's discovery be described?
2. What experiment was Roentgen making when he discovered a new type of rays?
3. How did he discover the rays?
4. What qualities do the X-rays possess?
5. In what ways are the X-rays used at present?

Ex 2. Translate into English:

1. В 1855 году Вильгельм Рентген открыл новый тип невидимых лучей, которые проникали через различные материалы.
2. Он поместил трубку Крукса в светонепроницаемый ящик и увидел странное свечение в углу лаборатории.
3. Поскольку известные ему лучи не могли проникать сквозь ящик, данный эффект вызывали неизвестные ему лучи; он назвал их «икс-лучи».
4. Рентген обнаружил, что «икс-лучи» проходят через многие непрозрачные материалы - дерево, алюминий и т.д., но лишь частично проникают сквозь кости человеческого тела и задерживаются свинцовыми пластинами.
5. Открытие Рентгена внесло большой вклад в развитие науки.

NUCLEAR POWER PLANTS

The energy for operating a nuclear power plant comes from the heat released during the fissioning of uranium or plutonium atoms in a nuclear reactor. This fission heat is used to generate steam, which drives turbine generator. Thus, there are two main differences between a nuclear power plant and a steam-electric power plant: the nuclear plant uses a nuclear fuel instead of a fossil fuel, and it uses a nuclear reactor instead of a boiler.

The fissioning of uranium-235 or plutonium-239 atoms - the primary nuclear fuels - is caused by the impacts of neutrons on these atoms. The fission process not only produces heat but also several additional neutrons that can cause fissioning of other uranium-235 or plutonium-239 atoms. Thus, by proper arrangement of the atoms of the fuel a sustained chain reaction can be maintained to provide a steady source of heat for operating a power plant. This chain reaction is controlled by regulating the number and the energy of the neutrons as they proceed from one fission reaction to another.

There are various types of nuclear reactors. The major differences between them are the form of the fuel, the methods for controlling the number and energy of the neutrons, and the type of liquid or gas used to remove the heat from the reactor core.

TEXTS FOR ADDITIONAL READING

Alfred Nobel - a Man of Contrasts.

Alfred Nobel, the great Swedish inventor and industrialist, was a man of many contrasts. He was the son of a bankrupt, but became a millionaire; a scientist with a love of literature, an industrialist who managed to remain an idealist. He made a fortune but lived a simple life, and although cheerful in company he was often sad in private. A lover of mankind, he never had a wife or family to love him; a patriotic son of his native land, he died alone on foreign soil. He invented a new explosive, dynamite, to improve the peacetime industries of mining and road building, but saw it used as a weapon of war to kill and injure his fellow men. During his useful life he often felt he was use less: "Alfred Nobel," he once wrote of himself, "ought to have been put to death by a kind doctor as soon as, with a cry, he entered life." World-famous for his works he was never personally well known, for throughout his life he avoided publicity. "I do not see," he once said, "that I have deserved any fame and I have no taste for it," but since his death his name has brought fame and glory to others.

He was born in Stockholm on October 21, 1833 but moved to Russia with his parents in 1842, where his father, Immanuel, made a strong position for himself in the engineering industry. Immanuel Nobel invented the landmine and made a lot of money from government orders for it during the Crimean War, but went bankrupt soon after. Most of the family returned to Sweden in 1859, where Alfred rejoined them in 1863, beginning his own study of explosives in his father's laboratory. He had never been to school or university but had studied privately and by the time he was twenty he was a skilful chemist and excellent linguist, speaking Swedish, Russian, German, French and English. Like his father, Alfred Nobel was imaginative and inventive, but he had better luck in business and showed more financial sense. He was quick to see industrial openings for his scientific inventions and built up over 80 companies in 20 different countries. Indeed his greatness lay in his outstanding ability to combine the qualities of an original scientist with those of a forward-looking industrialist.

But Nobel’s main concern was never with making money or even making scientific discoveries. Seldom happy, he was always searching for a meaning to life, and from his youth had taken a serious interest in literature and philosophy. Perhaps because he could not find ordinary human love, he never married/ he came to care deeply about the whole of mankind. He was always generous to the poor:

"I'd rather take care of the stomachs of the living than the glory of the dead in the form of stone memorials," he once said. His greatest wish, however, was to see an end to wars, and thus peace between nations, and he spent much time and money working for this cause until his death in Italy in 1896. His famous will in which he left money to provide prizes for outstanding work in Physics, Chemistry, Physiology, Medicine, Literature and Peace, is a memorial to his interests and ideals. And so, the man who felt he should have died at birth is remembered and respected long after his death.

THOMAS ALVA EDISON

Most people know that Thomas Edison invented the first working light bulb, but they don't know anything else about him. Edison had almost no formal schooling, yet he invented over 1 000 different things. Among Edison's inventions are; the phonograph (record player), the movie camera and the movie projector.

Thomas Edison invented his electric light bulb in 1879, but there was still much work to do. No one knew how to use electricity outside of a laboratory before Thomas Edison. He and his workers had to create a safe electric system. First they had to build a factory. Then they had to build the dynamos (generators) to make the electricity. Next they had to send out the electricity.

To show people that he was serious, Edison began his project in New York City. By 1887, much of New York City had electricity. Edison founded the Edison Electric Light Company and continued to supply electricity to New York and other places.

Thomas Edison lived until 1931. He continued to invent all his life.

After the War, he tried to invent a substitute for rubber because of the shortage that the war caused.

Thomas Edison was a true genius, but he never went to a college or university. The only time Edison attended school was when he was seven years old. He stayed for three months and never returned. Thomas Edison was a school dropout, yet he became one of America's most famous and most honoured man.

HENRI BECQUEREL

Henri Becquerel (1852—1908), a French scientist kept a collection of curious minerals in his desk. It so happened that in this desk were several boxes of unopened photographic plates. One day he decided to open one of the boxes and discovered that the plates were not only fogged, but intensively exposed. After studying these happenings he found that they must have been caused by rays given off from a mineral "pitchblende". Further investigation showed that the rays could pass through solid substances. If these rays had no penetrating power, they would not pass through solid substances. They could make gases good conductors of electricity, just like X- rays, which had been discovered only a year before.

These new rays needed no special equipment to produce them. It was found that the heavy elements- -uranium, thorium, actinium- gave out these radiations. In fact, the radiations went on naturally, and were quite unaffected by any chemical or physical action. This strange discovery was called "natural radioactivity", and scientists soon came to believe that the reasons for these happenings were to be found deep inside each atom of the substance.

Becquerel placed a piece of uranium inside a lead block, leaving only a thin hole to allow the escape of the radioactivity. By using a magnet, he showed that the radiations were of three different kinds. One was caused by negatively charged particles which the magnet bent to one side, and another kind was formed by positively charged particles, bent by the magnet in the opposite way. The third form of radiation was not bent in any way. The radiations carrying positive charges were called "alpha rays". The negatively charged particles were found to be fast electrons, and were named “beta rays". The rays that were not bent by the magnet were discovered to be X-rays of very short wave length, and were called "gamma rays”. If all the particles were electrically neutral as gamma rays are, they would not be deflected by a magnetic field.

BOHR, NIELS HENRIK DAVID

Danish physicist,

Nobel Prizewinner 1922 for theory of the hydrogen atom

Born: Copenhagen, October 7, 1885

Died: Copenhagen, November 18, 1962

One of the most sparkling and prolonged scientific jousting matches took place between Niels Bohr and Albert Einstein in the

20s and 30s. The latter, who could never accept the probabilistic nature of quantum mechanics, produced a series of gedanken experiments (thought experiments) designed to disprove the new theory. Bohr would then attempt to show where Einstein had gone wrong. In one of Bohr's successful attempts at this, he was especially pleased to note that Einstein had forgotten that according to his own theory of general relativity clocks run more slowly under the influence of a gravitational field.

In terms of scientific brilliance Niels Bohr is right at the top, perhaps second only to Einstein in the hit parade of 20th century scientists. It seems that every scientist who met Bohr came away with an impression of his deep intellect and his kind, gentle manner. (The phrase "large domed head" seems to occur frequently, too.)

Bohr lies at the end of a list of philosopher/scientists which charts the establishment of atomism in the scientific canon over the centuries: from the pre-Socratics Democritus and Leucippus; to Epicurus and Lucretius; to Dalton who was the first to create the concept of atoms in a modem scientific format; to Rutherford and Geiger who demonstrated the nuclear structure of the atom; to Bohr who was able to unite Rutherford's atom with the quantum concept of Planck.

Niels Bohr entered Copenhagen University in 1903, emerging in 1911 with his doctorate. (As if all his scientific gifts were not enough, Bohr was a shit-hot football player at university.) He then went on to study at Cambridge under J.J. Thompson then to Manchester under Rutherford. Rutherford was much more receptive to Bohr's new ideas and the two of them formed a very close personal and working relationship which resulted in Bohr producing his theory of the hydrogen atom in 1913 at the age of 27.

In 1911, Rutherford had postulated an atomic model which described the hydrogen atom as a small heavy nucleus surrounded by an electron in a fixed circular orbit around it. The only snag here was that this arrangement was completely forbidden by the laws of classical physics. According to Maxwell's equations, the electron, involved in circular motion hence accelerating, should be continuously emitting electromagnetic radiation. This energy could only come from the rotational motion, so the electron should spiral into the nucleus.

Bohr's masterstroke was to say that an electron was able to orbit the nucleus without emitting energy. Now, this mighty contribution to the advance of human knowledge might not have been so mighty had it not been accompanied by some more theory. Bohr said that many non-radiating orbits were allowed, each one having an integral factor of the basic unit of angular momentum, h/2*pi. When the atom absorbs radiation the electron is promoted from one fixed orbit to one of a higher energy (larger radius) and the energy of the photon is equal to the energy gap between the two orbits. Similarly, when an electron falls down from a higher energy orbit to a lower one it emits a photon of energy equal to the difference in energy between the two orbits. Thus the line spectrum of the hydrogen atom had been explained and the empirical formulae of Ritz, Rydberg and Balmer had received a theoretical explanation.

In 1916 Bohr returned to the University of Copenhagen as professor of physics where in 1920 they erected a special building to house the Niels Bohr Institute. Bohr's institute was supported financially by the Carlsberg brewing company, so it was … yes … probably the best institute of theoretical physics in the world … .

In the next decade this became the centre of the world for theoretical physics. Bohr's "Copenhagen school" produced the famous "Copenhagen interpretation" of quantum mechanics of which one of the main planks was Bohr's theory of "complementarity". For example, an electron can be regarded in two complementary ways - as a particle or a wave phenomenon with either being equally valid depending on the experimental circumstances.

One memorable quote from Bohr emerged after he had tried to explain quantum theory to a lecture room full of philosophers. He was amazed to find that all the philosophers sat there calmly and seemed to accept all the new ideas with nary a raise of the eyebrow. "Anyone who is not dizzy after his first acquaintance with the quan- turn of action has not understood a word", he said. On this point I can happily agree with Bohr. Speaking as someone who humbly attempts to teach quantum chemistry at university, I can testify to dizziness in my students after most lectures.

FIGURES IN RADIATION HISTORY

(Joseph John Thomson)

In 1884, at age 28, J.J. Thomson became a Director of the Cavendish Laboratory at Cambridge University. No one was more surprised than Thomson who had been decried as a "mere boy". Nevertheless, this mere boy turned what he described as a "string and sealing wax laboratory" into the world's preeminent center for experimental nuclear physics. It has been said that

Thomson, like Michael Faraday, was greater than his discoveries. However, those discoveries were far from insignificant. Thomson and his student Ernest Rutherford were the first to demonstrate the ionization of air by X rays. So fundamental is this phenomenon that the phrase "ionizing radiation" remains the most concise way to characterize the wide range of electromagnetic and particulate radiation emitted by atoms. Nevertheless, Thomson is best known for his investigations into the nature of "cathode rays", (i.e., electrons). By deflecting these "rays" with an electric field, something that had been done previously with a magnetic field, Thomson provided conclusive proof that they were negatively charged particles. He determined their mass to be one two- thousandth that of the hydrogen atom, the smallest object known at that time. Thomson was thus the first to identify the existence of sub-atomic particles. This opened the door to a new world of which his student, Ernest Rutherford, would later master, as well as provide his own significant contributions to nuclear physics. Later, Thomson demonstrated that the interaction between electrons and matter produced X rays and that X rays interacting with matter produced electrons. Although it would fail the test of time, Thomson is usually credited with the first "modem" model of the atom, the so-called "plum pudding" model. In it, he pictured a sphere of positive charges mixed together with an equal number of electrons (i.e., negative charges). For his theoretical and experimental investigations into the electron and the conduction of electricity by gases, Thomson was awarded the 1906 Nobel Prize in physics. Ironically, Thomson, who had characterized the material properties of electrons, would live to see his son George P. Thomson receive the Nobel Prize for experimentally confirming the wavelike properties of electrons.

QUANTUM REALITY

Without quantum mechanics most of twentieth-century science, and much of its advanced technology, would not exist. Yet the Nobel Prize winning American physicist Murray Gell-Mann has described quantum mechanics as 'that mysterious, confusing discipline which none of us really understands but which we know how to use'. While Richard Feynman recommended that physicists stop trying to fathom out its meaning: 'I think I can safely say that no-one understands quantum mechanics... Do not keep asking yourself, if you can possibly avoid it, "but how can it be like that?" … Nobody knows how it can be like that.'

Why should two of the century's most distinguished physicists not 'understand' one of great scientific theories of modem science? What kind of theory can be so difficult that nobody understands it?

Quantum mechanics is not terribly difficult to understand mathematically. Any graduate student of theoretical physics understands its mathematical structure and its computational power. The problem that lies at the centre of quantum mechanics is that of interpretation. What does the theory 'mean'? What does quantum mechanics reveal about the nature of reality? It is when physicists have tried to address such questions that the reactions of Gell-Mann and Feynman have been commonplace.

There have been many attempts to make sense of quantum mechanics. The 'orthodox' interpretation, accepted by several generations of physicists, was formulated by Niels Bohr and Werner Heisenberg and came to be known as the 'Copenhagen interpretation1, because Bohr was the director of the Institute of Theoretical Physics in the Danish city. The reality envisaged in the Bohr-Heisenberg interpretation was not an objective, but a phenomenal one. It did not exist in the absence of observation. This was a view that Albert Einstein found so unacceptable that for the last 30 years of his life he argued against it.

The Birth of the Quantum

The idea of the quantum was born on 14th December 1900, when the German physicist Max Planck reluctantly announced that certain experimental results could only be understood if energy was emitted or absorbed in certain discrete packets, which he called 'quanta'. This idea could not be accommodated within the existing Newtonian framework, in which energy could have any value and was transmitted not in discrete amounts, but in an endless stream. Planck grasped enough of the quanta's significance to feel exceedingly unhappy about it, as a near contemporary noted: 'He was really a revolutionary against his own will... He finally came to the conclusion, "it doesn't help. We have to live with quantum theory. And believe me it will expand. It will not only be optics. It will go in all fields. We have to live with it".'

Physicists did have to 'live with' the quantum hypothesis; but they also used it. Niels Bohr was one of the first. He introduced the quantum idea of discontinuity directly into the atom in an attempt to develop a satisfactory model of atomic structure.

The most widely accepted theory of the atom at the turn of the century was J.J. Thomson's 'plum pudding' model. The Thomson atom was a sphere of positively charged matter in which was embedded, like plums in a pudding, negatively charged electrons. However, by 1911 experiments forced Ernest Rutherford to put forward a planetary model of the atom in which a positively charged nucleus was orbited by negatively charged electrons.

The Rutherford atom, however, was no sooner announced than it was beset by a problem. In classical physics, electrons orbiting a nucleus should radiate energy continuously and quickly spiral into the nucleus. So when Niels Bohr joined Rutherford's team, in 1912, he was immediately set the task of tackling the problem of atomic stability. Bohr believed that if the inevitable collapse suffered by the Rutherford atom was to be overcome, then a break with classical physics was required

In the Bohr model, an electron still orbits around the atomic nucleus, but is no longer sent spiralling into it. Bohr's solution involved patching together classical physics with quantum theory. He took the orbiting electrons from

Rutherford's model, and argued that they could not spiral into the nucleus by emitting radiation continuously, since radiation could only be emitted in quanta, discontinuously.

Moreover, Bohr's electrons were confined to certain 'stable' or 'stationary' orbits and no others. The permitted orbits were characterized by certain fixed amounts of energy. As long as an electron remained in one of these 'stable' orbits or 'energy levels', it could not absorb or emit radiation.

Einstein's Photon

In 1801, in one of the most famous experiments in science, Thomas Young demonstrated that light was a wave-like phenomenon. The modem version of Young's two-slits experiment runs as follows. Two very narrow, close and parallel slits are illuminated by light from a single slit parallel to them, and placed directly in front of a mono-chromatic light source, such as a sodium discharge lamp. The two slits act as new sources of light once the sodium lamp is switched on. On a screen placed some distance in front of them, a pattern of dark and light bands known as 'fringes' can be seen. Only if light is a wave phenomenon can these fringes be explained as the interference of two light waves originating from the two slits. As soon as one of the slits is covered up, the fringes disappear.

Einstein, who was the first to learn to live with the quantum hypothesis, threw physicists into some confusion about the nature of light when, in 1905, he successfully explained the so-called photoelectric effect by taking light to be composed of particles, not waves.

The photoelectric effect was first observed by Heinrich Hertz when he noted that the space between two metallic plates, oppositely charged and contained in an evacuated tube, became a better conductor when illuminated by ultraviolet light. The effect is due to electrons (called photoelectrons, hence the term 'photoelectric') being emitted from a metal surface when it is illuminated by light.

One of the features that Hertz's experiments revealed was that the maximum kinetic energy (energy due to motion) of the photoelectrons did not depend upon the intensity of the light beam striking the metal surface, but only on its frequency. Furthermore: the emission from any particular metal surface occurred only when the frequency of the beam of light that struck it was above a certain minimum value. For frequencies above this minimum, the emission of the photoelectrons occurred immediately, even when the intensity of light was very low.

These were all very surprising results. Einstein explained them by extending Planck's quantum hypothesis to light. For Einstein light was not a continuous wave-phenomenon, but quantized into packets - later called photons. According to Einstein, in the photoelectric effect a beam of photons strikes the metal surface, whereupon the photons give electrons in the plate enough energy to escape. The fact that the energy given to an electron is dependent upon the frequency of the light used indicates that the energy of a photon is proportional to the frequency (or inversely proportional to the wavelength) of the light. The greater the intensity of the incident beam of light, the greater the number of photons and consequently the greater the number of photoelectrons emitted.

Wave-Particle Duality

Einstein's light-quanta provided an explanation of the photoelectric effect, but the photon description of light could not be invoked to explain the wave phenomena associated with light as revealed by Young's experiment. Einstein eloquently expressed the widespread unease in the physics community at having to use 'two theories of light, both indispensable, and - as one must admit today despite 20 years of tremendous effort on the part of theoretical physicists - without any logical connection'.

What Einstein meant was that both the continuous wave and discontinuous quantum descriptions are in some way valid; light has a dual wave-particle character. But if this concept took some thinking about, it was the discontinuity brought into physics by the quantum hypothesis that scientists found most difficult to accept. Planck had introduced that hypothesis only when all other possibilities were exhausted. Though he believed, as most physicists did, that radiation was both emitted and absorbed in discrete quanta of energy, he continued to maintain that this radiated energy travelled through space in a continuous wave. Experimental results, however, made the view put forward by Planck inconsistent with the available scientific evidence. In 1923 a further blow was struck against Planck's interpretation by the French aristocrat Prince Louis de Broglie when he suggested that not only light, but all particles had a dual character.

Now the problem facing physicists was how to explain this wave-particle duality. To paraphrase and extend Einstein's point, there were now two theories, not only of light, but also of matter. Both were indispensable, yet the two were without any logical connection.

The Birth of Quantum Mechanics

The state of quantum theory at the beginning of 1925 has been described as 'a lamentable hodgepodge of hypotheses, principles, theorems and computational recipes'. The situation was to be rapidly transformed in September of that year when Werner Heisenberg published a remarkable article entitled 'On a Quantum-Theoretical Reinterpretation of Kinematics and Mechanical Relations'. His stated aim was ambitious: 'to establish a basis for theoretical quantum mechanics, founded exclusively on relationships between quantities which, in principle, are observable.' 15 pages later, the aim was achieved, and Heisenberg had laid the foundations for a quantum mechanics of the atom and its interactions.

At the time most physicists were unfamiliar with the mathematical techniques employed by Heisenberg and were more inclined towards the version of quantum mechanics developed by the Austrian Erwin Schrodinger. Although the terms and concepts used by Schrodinger were more familiar, the underlying ideas were just as revolutionary. Schrodinger introduced the notion of treating electrons as standing waves - a novel move away from thinking of electrons as particles.

A standing wave is formed when two waves, travelling in opposite directions, synchronize exactly. If the idea of standing waves is applied to Bohr's model of the atom, an electron's orbit can also be regarded as a standing wave. Each time an electron completes an orbit, it has travelled a distance, into which only a certain number of whole standing waves can fit. Schrodinger elaborated this idea into a fully-blown theory in which the quantum conditions that were invoked ad hoc in the Bohr atom were found to arise from fundamental postulates. Schrodinger believed he had explained why certain electron orbits were forbidden in the Bohr model. Only those orbits into which the whole numbers of standing electron waves could be fitted were possible.

Heisenberg and Schrodinger put forward different formulations to account for the paradoxes thrown up by quantum physics. But if we look at the interpretation of the new physics, what is significant is that both formulations were widely taken to undermine the premises of objectivity and determinacy that are central to classical science.

TEXTS FOR TRANSLATION

Fundamental Physics: Resistance of a Perfect Wire

Intuition tells us that a wire without defects should have zero resistance. But in the real world all conductors, however perfect, have some resistance. A new study confirms that electrical contacts are the problem.

It is the dream of physicists and electrical engineers alike to build electronic devices that can conduct electrical currents with the minimal amount of resistance. The miniaturization of electronics will soon lead to devices of the smallest possible physical dimensions, in which quantum effects become important. In this context, the ultimate conductor would be a very thin one-dimensional wire that has no defects to inhibit resistance-free currents. Electrons in such a wire are ballistic — that is, the wire is so clean that the distance travelled by the electrons between collisions is longer than the wire itself. On page 51 of this issue de Picciotto *et al*.[1] describe electrical conduction in a nearly perfect, ballistic one-dimensional wire. This groundbreaking work helps to establish fundamental limits on the current-carrying capacity of ideal wires and their connections.

Imagine a perfect, extremely thin, straight wire in which electrons are allowed to move only along the wire. A perfect wire has no defects, kinks or obstacles other than a connection at each end to allow current to pass through an external circuit, and perhaps two probes along the wire to measure the voltage (Fig. 1a). Will the motion of the electrons and hence conduction of electricity in this wire proceed without resistance? De Picciotto *et al.*[1] have created this imaginary wire in the laboratory. They find that the resistance of a wire can be separated into two parts: an 'intrinsic resistance' due to the scattering of electrons by imperfections in the wire, and a 'contact resistance' associated with the connections to the external circuit. The intrinsic resistance is measured by the two voltage probes, which draw negligible current. The authors find that in their defect-free wire the intrinsic resistance does actually reach zero, although there is a finite contact resistance of around 13 kΩ.

The vanishing of the intrinsic resistance agrees with the simple notion that the current-carrying electrons should move freely if there are no obstacles. Our picture of electrical resistance as the result of momentum-changing deflections on charge-carriers dates back to the work of Drude around 1900. The most effective deflections are those that scatter charge-carriers in the opposite direction to that of their flow. In the late 1950s, Landauer[2] became fascinated with the idea of electronic miniaturization and proposed a conceptual framework for understanding electrical conduction in one-dimensional wires. Landauer realized that the wire can be thought of as being connected to electrochemical potential reservoirs, in which many electrons of different energies are available for conduction (Fig. 1b). Once an electron enters the wire it cannot change energy, and only momentum changes can affect the electrical current. So where the wire is connected to the reservoirs there is a mismatch of energies and a contact resistance develops. Conversely, in a regular three-dimensional wire, the contact resistance is very small and so tends to go unnoticed. But in a one-dimensional conductor, with no impurities, the intrinsic resistance must vanish although the contract resistance is high.

Until the 1980s most current measurements on mesoscopic devices (typically a micrometre or less in size) used a two-terminal geometry, in which voltage difference is measured solely between the current source and drain. But after Webb *et al.*[3] developed the technology to place multiple terminals on small metallic wires and rings, it was discovered that the four-terminal — two voltage probes in addition to two current leads — resistance of a non-ballistic wire changes if the direction of an external magnetic field is reversed. This unexpected result was explained by Buttiker[4], who generalized Landauer's ideas to devices with multiple terminals. He pointed out that, in the absence of magnetic impurities, a four-terminal resistance should be unchanged by swapping over the current and voltage probes and reversing the magnetic field.

After considering the multiple-terminal case, Buttiker proposed that a two-terminal resistance must always contain a contact resistance, even if the wire is ballistic. This contact resistance can be measured directly between point contacts that are shorter than the mean free path of electrons in a non-ballistic conductor[5, 6]. Two-terminal measurements of ballistic wires also found their resistance to be quite large, around 13 kΩ. Is this resistance just the sum of the contact resistances?

De Picciotto *et al*.[1] have built a multi-terminal one-dimensional conductor to address this issue. Classically a wire is considered to be one-dimensional if its width exactly accommodates the size of the charge carriers with no room for wiggling. Electrons are essentially point objects, so this is technically unfeasible. But this is where quantum mechanics comes to the rescue. If an electron is made to occupy the lowest quantum-mechanical energy state in the lateral directions, without access to higher excited states, it would be free to move only in one dimension. The key is to confine electrons so tightly that the energy levels of the excited states are too high for them to reach. One way of doing this is to cool the wire to sufficiently low temperatures — but not superconducting temperatures — so that the excited states are thermally inaccessible and conduction is strictly one dimensional.

To create the perfect one-dimensional wire, de Picciotto *et al*. use a precise semiconductor growth technique called cleaved edge overgrowth[7] to grow alternate crystalline layers of GaAs and AlGaAs in orthogonal directions, which form a neat edge. Even more remarkably they have succeeded in attaching non-invasive voltage probes to the minuscule wire. The GaAs/AlGaAs sheet forms a two-dimensional electron gas, and the authors place metallic electrodes on the surface to isolate the one-dimensional wire from the rest of the sheet (Fig. 1c). When negative voltages are applied to these electrodes they deplete the two-dimensional electron gas beneath them but preserve the one-dimensional wire along the edge. The width of the metallic electrodes defines the length of the isolated wire. The separation between the electrodes also creates two narrow strips in the two-dimensional electron gas that act as voltage probes.

This set-up allows both four-terminal and two-terminal measurements to be made on the same wire. In order to measure the intrinsic resistance, it is essential that the voltage probes do not disturb the current flow. With a one-dimensional wire this is usually impossible, but in their system de Picciotto *et al*. can tune the effect of the voltage probe until it is almost non-existent. They show that whereas the intrinsic resistance measured between the non-invasive voltage probes vanishes, the two-terminal resistance of about 13 kΩ can be directly attributed to the current contacts. This non-zero contact resistance indicates that there is a minimum resistance for the passage of electricity regardless of how perfect a wire may be.

It would be interesting to explore the possibility of circumventing the limitations imposed by the presence of contact resistances. One can imagine measuring the electrical properties of one-dimensional conductors using a contact-free method, such as capacitance coupling, to induce charge motion. The results of studies like that of de Picciotto and colleagues will apply equally to carbon nanotubes and other one-dimensional systems, and will become increasingly important as electronics gets ever smaller.

Research into the Creation of the Laser-induced Fluorescence Diagnostics of the Condition of Heart Tissues, Transplants and Allografts in Cardiosurgery

Project Summary

The goal of the proposed Project is to study the reaction of biological structures to laser irradiation and to develop methods of integral evaluation of changes in the state and viability of biological tissues based on laser-induced fluorescence (LIF).

Evaluation of viability of donor tissues and organs used for transplantation is an important factor influencing the transplantation result. Initial unsatisfactory state of the donor heart tissues causes 15-20 % of intraoperative deaths. Thus, the problem of preliminary control of viability of tissues and organs supplied for operation, either being preserved or restored from conservation, and used for transplantation has become especially urgent. Unfortunately, no universal system for evaluation of the quality of transplants. That's why development of new methods for appropriate evaluation of the state of donor tissues and organs is urgent, necessary and practically important.

Control of the state of a transplant in the postoperative period is of great importance. In spite of on-going studies for development of methods of noninvasive evaluation of the transplant rejection crises, which is especially important during the first year post operation, there is no alternative to endomyocardial biopsy. Performing endomyocardial biopsy itself can cause a number of complications associated with surgical manipulations. Taking into account the need for multiple operations of the type, it becomes obvious that the risk of complications developing in a patient becomes extremely high. The above data once again point to necessity, urgency and practical importance of search for new methods to evaluate the state of the transplanted (donor) organ and development of low-invasive methods of diagnostics of rejection crises post operation.

Many cardiac pathologies of different geneses are combined with mineralization (calcinosis) of tissues, especially in patients with valvular disease of the heart. Carrying out any surgical manipulations on the valvular system of a calcinosis-affected heart can be accompanied by fragmentation of tissues, which in its turn, is a prerequisite for a dangerous postoperative complication – material embolism. The process of mineralization of valves is a limiting factor for plastic cardiosurgery. It is the mineralization degree of valvular endocard and paravalvular structure that plays the decisive role in predicting the results of therapy and the outcome for a patient. That’s why quick and timely intraoperative diagnostics of fragments of calcinated tissues in the heart cavity can become a method for prophylaxis of this complication.

New appropriate and quick methods for diagnostics of the state of donor heart tissues are available. At the same time, development of fundamental research in the field of creating laser sources and studying their effect on biological samples opens new broad prospects for the use of lasers in biology and experimental and practical medicine. Laser technologies are already widely used in clinical practice. The recent experience of research work shows that lasers can used for therapy of many complicated diseases, including oncologic ones. At the same time, the general possibility of use of lasers for diagnostics of vascular sclerosis and atheromatosis and intestinal neoplasms has been reported for the first time. However, the method of laser diagnostics of the state of tissues and organs in practical medicine, including cardiosurgery, has not been developed yet. Based on the above considerations, it seems more promising to develop a method for quick and exact diagnostics of the state of donor hearts using technologies involving the use of laser irradiation.

At the same time, it seems promising to use not only tissues and organ cultures having a complicated morphology but also individual structural components in a cell culture in vitro in order to develop the reaction of the biological sample to laser irradiation and to create a data bank.

Favorable conditions are now available at IT&AM, SB of RAS; SRC VB "Vector" and RI BCP, RF MH for carrying out such studies. Radiation sources and experience of research on the use of laser-induced fluorescence in medical studies in cooperation with RI BCP, RF MH, are available at IT&AM. A base for carrying out works on creation, certification and cultivation of cells of different animal organs and tissues has been created at SRC VB "Vector". The Center has a group of highly-qualified specialists and necessary equipment and premises.

Taking into all the above, it appears to be necessary and expedient to carry out studies on development of methods based on laser-induced fluorescence, diagnostics of viability state of donor heart tissues before operation (including the state of allografts and transplants) and that of low-invasive methods of evaluation of rejection crises post operation as well as intraoperative diagnostics of fragments of mineralized tissues in operations on valves.

Basic activities:

1. To investigate the effect of laser irradiation on cell cultures in vitro, animal and human tissues or organs ex vivo experiments.

2. To determine the parameters of laser irradiation which does not injure cells and tissues but allow to evaluate their state and to develop methods to control the state of live tissues.

3. To create a data bank on LIF spectra of cell cultures cultivated in vitro and being at different viability states and different cardiac tissues, both healthy and pathology-affected ones. To decode molecular mechanisms of photobiological reactions. To identify the most active enzymes and macromolecules of in the cell and to study the key stages of formation of LIF spectrum accompanied by identification of the most active components, radicals, molecular bonds, etc.

4. To carry out comparative studies on identification of the state of cells and tissues by LIF spectra and the data of traditional clinical and laboratory analysis. To study the mechanisms of functionally active light absorption. To study the mechanisms of the effect of ultraviolet irradiation on protein (cells) - their inactivation, i.e. loss of enzymatic, regulatory, hormonal, transporting and immunological activities. To determine the quantum outputs of photoinactivation of proteins. To investigate the energy migration in proteins. To determine contact rates of reactions of the photochemical, luminescent and thermodynamical way of deactivation of electron-excited state of molecules absorbing ultraviolet quantum of light.

5. To develop methods for:

• appropriate diagnostics of viability state of donor heart tissues before and post operation (including the state of allografts at different technological stages);

• intraoperative diagnostics of fragments of mineralized tissues at operations on valves;

• low-invasive evaluation of rejection crises after operation of heart transplantation.

6. To obtain safety for the method being used for diagnostics in clinical practice and to develop methodological recommendations on the method application.

To provide the proposed Project implementation it is planned:

• to develop methods to control the cells exposed to laser irradiation;

• to obtain data on the effects of different doses and conditions of laser irradiation on model cell cultures in vitro and animal and human tissues and organs in vivo;

• to identify conditions of laser exposure which provide appropriate evaluation of viability of cells in vitro and tissues and organs in vivo;

• to develop a method for diagnostics of viability of tissues and organs in vitro and vivo;

• to investigate the method's safety in laboratory animals;

• to obtain comparative data on the method's efficiency in patients as compared to traditional methods of control of tissues and organs.

The studies to be performed will allow to obtain for the first time data on spectra of tissues and organs, both normal and with affection of different nature, and to develop new methods for diagnostics of the state of donor issues and organs. Besides, the Project implementation will provide new fundamental knowledge of reaction of biological objects to laser irradiation. This knowledge is required not only for development of methods for diagnostics of the tissues viability and vital activities but, possibly, for development of new therapeutic methods as well. As a result of the Project implementation, the question will be answered about the general possibility of LIF being used for integral evaluation of the state of donor tissues before operation, development of low-invasive evaluation of crises of transplants rejection and intraoperative diagnostics of mineralized fragments of cardiac tissues.

Thus, urgency and scientific novelty of the Project consists in obtaining fundamental knowledge of reaction of live tissues and cells to laser irradiation. This knowledge will allow to work out approaches to the development of a technology for diagnostics of affected tissues of the heart and other organs, which will be new not only for Russia. The Project implementation will provide new possibilities for practical medicine in Russia and abroad and will open new promising trends of research work. Laser diagnostic methods for evaluation of viability of donor tissues and organs (allografts and donor hearts for transplantation) will be commercially valuable. These methods will serve as a basis for achieving better results of surgical treatment of patients with cardiac pathologies, which is of scientific and practical interest for medicine both in Russia and abroad.

Similar studies are underway in Lawrence Livermore National Laboratory (LLNL), USA, collaborator in these activities.

The Project activities will allow to use experience and knowledge of specialists, who have dealt with the problems of biological safety (SRC VB “Vector) and have been involved in research for development of rocket and laser weapons (IT&AM, SB of RAS), for developing a new technology which will be very important both for fundamental science and the needs of public health service. Besides, involvement of specialists of SRC VB “Vector” and IT&AM, SB of RAS, will help to solve the social problem of changing the character of the personnel’s activities, which meets ISTC goals and objectives.

Constant Changes

If a constant of nature can vary, then so might laws of physics

Sometimes it's the tiniest differences that change everything. This summer, astrophysicists reported tantalizing evidence of just such a discrepancy.

Using one of the world's largest telescopes, a team of Australian, British, and U.S. astrophysicists observed clouds of gas in space backlit by beams of radiation from ancient, superpowerful quasars.

By doing so, they have found evidence that one of the constants of nature, which are never ever supposed to vary, was smaller billions of years ago than it is today. The quantity that was measured, known as alpha, wasn't smaller by much—less than 1 part in 100,000—but the finding has sent tremors through physics and astronomy.

"Atoms, the whole periodic table, and the way it exists are dependent on the value" of alpha, notes Barry N. Taylor of the National Institute of Standards and Technology (NIST) in Gaithersburg, Md. "If alpha didn't have the value it has, Earth as we know it wouldn't exist," he adds.

Other striking interpretations of the new data are also possible. For instance, a changeable alpha may indicate that extra dimensions of space exist beyond the three familiar to us.

On the other hand, a much less exotic explanation may lurk behind the new measurement of alpha—it may simply be an error. "It's a pretty amazing result, so you have to treat it with extreme skepticism," admits the team's leader John K. Webb of the University of New South Wales in Sydney, Australia. Although no flaw has been found so far in the study, researchers are rushing to measure alpha's ancient value by other approaches that wouldn't be prone to the same potential sources of error.

Electromagnetic force

Alpha is known formally as the fine-structure constant. On its Web site, NIST defines this constant as "the strength of the electromagnetic force that governs how electrically charged elementary particles (e.g., electrons, muons) and light (photons) interact."

Since the universe was born some 15 billion years ago, it has ceaselessly expanded and changed. Nonetheless, a few characteristics of the cosmos appear to have remained immutable across all of space and time. These fundamental constants of nature include alpha, the gravitational constant, and the speed of light in a vacuum.

The constants have been viewed as fixtures of reality. They are part of the foundation of physics, embedded deeply in both the classical science and quantum mechanics, as well as in relativity and the so-called standard model of particle physics.

If the measured variation in alpha turns out to be real, then one of the most basic assumptions of science—that the laws of physics are the same everywhere and at all times—will prove untrue, notes Michael S. Turner of the University of Chicago.

"Constants are invented by man to help him describe the natural world that he sees. You have to keep that in mind," points out Taylor, a physicist who since the 1960s has been a leader in assessing the values of constants.

Physicists periodically recheck those values partly because advances in instrumentation enable them to measure the quantities with greater precision. New, improved measurements, in turn, lead to refinements in all calculations that depend on the constants' values.

Also, since the constants and their values are integral components of the leading theories of physics, searching the universe for discrepancies in those values is a way to grope for cracks in current physical understanding. "There's a whole industry of people thinking about the variation of constants," Taylor notes.

One way that that industry looks for such inconstancy is to examine what colors of light are absorbed by giant gas clouds floating far out in space. Many such clouds dot the universe, and some conveniently lie between Earth and brilliant quasars.

From high-precision laboratory experiments, scientists know that some atoms, primarily metals, absorb two or more wavelengths of radiation separated by a telltale spacing. So, when patterns of dark absorption lines with just those spacings show up in the spectra of quasars, astronomers conclude that an intervening gas cloud contains particular types of atoms.

Since the late 1960s, observers have been checking to see whether the spacings between the absorption lines in quasar spectra differ slightly from those observed in laboratory experiments. According to theory, alpha is one of the factors that affects the size of the spacings. So, if alpha during the earlier phases of the universe was slightly off from today's value, that difference might show up in the spectra of quasar light traversing gas clouds on its way to Earth.

That's where the new spectral measurements that Webb and his colleagues harvested come in. In the Aug. 27 *Physical Review Letters,* they present data suggesting that the spacings between absorption lines for several types of atoms 8 to 12 billion years ago were different than they are today.

In their analysis of spectra from 49 different gas clouds, the researchers find consistent evidence that alpha was smaller in the early universe. The difference from today's value of 0.007297352533 is minuscule, affecting only the seventh decimal place and beyond.

More evidence for the discrepancy appears to be on its way. Webb says that a preliminary analysis of an additional set of observations twice as extensive as the one described in the Aug. 27 report also indicates that alpha was once a wee bit smaller than today.

The team is able to discern such a tiny discrepancy thanks to a combination of factors including better instruments and a focus on elements that have many absorption lines, says Christopher W. Churchill of Pennsylvania State University in State College, an astronomer and a coauthor of the new report.

The first hints that alpha was smaller in the distant past than it is now came in 1999. However, those findings were less robust than are the latest ones because they relied on data from fewer clouds and fewer types of atoms in those clouds, Churchill notes.

The new finding is "one of those results that's extremely important . . . if it's true," comments David N. Spergel of Princeton University. Adds Taylor, "To the best of my knowledge, there's been no definitive observation of a time variation in a constant. This case may be the strongest that we've seen."

A slight variation

The implications of even a slight variation in alpha are many. The grand scale of some of these may explain why the John Templeton Foundation of Radnor, Penn., a spiritual organization with a goal of using new scientific discoveries to broaden theology, is in part supporting the research by Webb's team. On its Web site (http://www.templeton.org/), the foundation states that it takes particular interest in evidence that some unseen hand is molding the universe over time.

One of the most profound implications for science would be that the presumption of immutability for the laws of physics may be wrong. Although the universe is full of evidence of the constancy of these laws, the new finding suggests that "maybe there's a tiny violation of that," says Turner, a cosmologist.

On the other hand, it may not prove easy to distinguish a revision of the laws from merely a better understanding of parameters found in those laws.

As an example, Turner points out the accepted theoretical claim that elementary particles known as the W boson and the Z boson had no mass when the universe first exploded into being. Modern accelerator experiments have shown, however, that both are very massive today. Even so, physicists have not concluded that the laws of physics have changed. Instead, they envision that as the universe evolved according to the steady laws of physics, the inherent possibility for W and Z bosons to become massive was realized. Something similar may be behind the apparent discrepancy between ancient and modern values of alpha.

Taylor explains that the laws that describe the forces between charged particles, such as atomic nuclei and electrons, wouldn't necessarily change even if the values of alpha or other parameters do in fact vary. However, if alpha has enlarged in the past 12 billion years, the strength of that atom-binding force would have grown slightly. "I would take the view that, until we know better, the law might be universal but the values of these parameters may be time-dependent. It's hard to say," he adds.

String theory

In the 1990s, the burgeoning branch of physics known as string theory fueled efforts to find variation in fundamental constants. In string theory, the fundamental particles of the universe are not points as they are in today's dominant theories. Instead they are vibrating, elongated stringlike entities. And, there are not just four dimensions—three spatial ones and time—but as many as 11 (SN: 2/19/00, p. 122: http://www.sciencenews.org/20000219/bob1.asp).

According to some string models, the values of certain constants are dependent on the scales of those extra dimensions. Although today those extra dimensions would remain tightly curled up and hidden on subatomic scales, some of them may have been more spread out shortly after the universe was born.

Although the string-theory models suggest that alpha variation would have taken place much earlier in the universe than 12 billion years ago, Webb's team may be seeing a "tail" remaining from a larger, earlier variation, Turner speculates. In any case, an ancient, slightly diminished alpha might be a sign that extra dimensions exist, and it might provide a coveted window onto their properties, says John D. Barrow of the University of Cambridge in England, a theorist on the varying-alpha team.

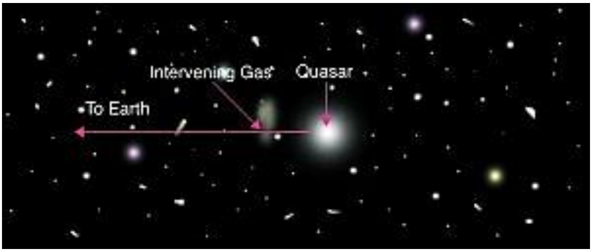
Complicating the interpretation of a once-smaller alpha, the quantity's magnitude relies on the values of other fundamental constants. Those are the size of the electron's charge, the speed of light, and Planck's constant, which defines the scales at which quantum phenomena operate.

A once-smaller alpha, therefore, could indicate that radiation may have zipped around slightly faster in the early universe than it does today, Webb says. As a result, interactions might have been possible between more widely separated regions in the early universe than in today's. That, in turn, might have affected the uniformity of the universe and some of its other properties, Webb adds.

Alpha's growth

Alpha's possible growth since the distant past also raises the question of whether it is still in flux today. This June in Seattle at a meeting about controlling frequencies of atomic clocks and other devices, Sébastien Bize of the Paris Observatory and his colleagues reported fresh evidence that alpha is holding steady. Using the world's most precise clocks, known as atomic fountain clocks (SN: 8/7/99, p. 92), the scientists have made a preliminary estimate that the annual variation in alpha, if any, must be less than 1 part in 100 trillion

Although the measurements in the clock experiments indicate that alpha's value now is fixed, they don't cast doubt on the new astrophysical findings, Bize says. The minuscule disparity that turned up in the quasar spectra covers 12 billion years, which would correspond to an average annual shift of 1 part in 1,000 trillion. That's smaller than the clock laboratories can currently detect. What's more, it may be that the rate of change in alpha itself varies.



As light from a distant quasar pierces a gas cloud billions of years ago, atoms absorb some colors. The precise wavelengths of the lost colors suggest to astronomers that the seemingly constant strength of light's interaction with matter has not, in fact, always been the same. Based on M. Murphy/UNSW

That's exactly what Barrow and a couple of other theorists have proposed in a theoretical model they posted July 26 on the Internet physics preprint archive (http://xxx.lanl.gov/abs/astro-ph/0107512). They suggest that alpha stopped being a variable about 3 or 4 billion years ago when the expansion of the already-ballooning universe presumably began accelerating (SN: 2/12/00, p. 106: http://www.sciencenews.org/20000212/bob1.asp).

Still, in this model, which agrees with the astrophysical data but has no obvious ties to string theory, the gravity of massive objects such as stars may also tweak alpha's value. Bize says the

Paris experimenters plan to probe this possible gravitational influence in future tests. To do so, they'll compare frequency measurements of fountain atomic clocks when Earth's orbit carries it relatively near or far from the sun's gravity.

Taking an alternative approach to the problem, Webb and his coworkers have launched a program of radio telescope observations. The researchers will employ equipment quite unlike the optical instruments, such as the 10-meter Keck I telescope in Hawaii that they previously used to make spectral observations of gas clouds. Radio astronomy also homes in on different substances in the clouds, including carbon monoxide and other organic molecules, Webb explains.

Other, more radically dissimilar means may also provide a cross-check on the ancient value of alpha. In one, scientists plan to analyze subtle fluctuations in the cosmos discerned by satellite-based telescopes. Those telescopes generate sky maps of relic radiation, known as the cosmic microwave background (CMB), that dates from not long after the birth of the universe (SN: 6/23/01, p. 394: http://www.sciencenews.org/20010623/bob12.asp).

Almost a year ago, a team of Portuguese and British scientists proposed that the microwave pattern favored an ancient alpha that was smaller than today's. However, says Spergel, those microwave data have since been reanalyzed, weakening that interpretation.

Measurements to come may tilt the scales one way or another. For example, the recently launched Microwave Anisotropy Probe, or MAP, satellite can measure the CMB's faint glow with 100 times the precision that has been available. MAP's successor, dubbed Planck, is slated to launch around 2007 and should detect variations in the CMB with even greater precision.

"When the [CMB] data gets better, we'll see either [the radiation pattern predicted by] the standard model or we'll see a signature for something new, like this time-varying alpha," Spergel says.

If the slight shift in alpha measured by Webb and his colleagues holds under further scrutiny, then scientists may have to forgo their long-held ideal that the constants of nature are perpetually unchanging.

PHYSICAL PROPERTIES OF NANOMATERIALS

Introduction

Although the interest in nanotechnology has reached its peak only recently, the concept of nanotechnology itself has been known for more than 50 years. In the article titled “There's Plenty of Room at the Bottom″(1959), physicist Richard Feynman concluded that according to the existing physics laws, there is no reason why materials could not be “created/manufactured” by manipulating single atoms. Besides Richard Feynman, we need to mention Professor Nori

Taniguschi, who first introduced the word "nanotechnology" (1974), as well as the recipients of the Nobel Prize Harold W. Kroto, Richard E. Smalley, and Robert E. Curl, who discovered the fullerene = a .ball-like form of carbon that showed a lot of potential as a building material in manufacturing miniature size objects. An unexpectedly discovered form of carbon, named Buckyballs or Fullerenes after eccentric architect Buckminister Fuller, was declared the molecule of the year by the "Science" magazine in 1991. (Hawkins et al, 1991, pp.312-313)

Progress in the field of nanotechnology was prompted by the development of advanced electron-scanning tunneling microscopes used for observing nano objects. The variety of nanomaterials is vast, just as is the range of their properties and possible applications. We can say that, with nanotechnology, the boundaries between different scientific disciplines are disappearing. Therefore, we can label it as converging technology and we need an interdisciplinary approach to it. Because of its far-reaching and various fields of applications, it is believed that nanotechnology has an enormous potential.

Nanomaterials and Nanoparticles

Nanometer, nanoparticle, ultaramicrosize, nanophase materials are all different terms used for materials with their grain size of the order of a few nanometers (El-Shall & Edelstein, 1996, pp.29-70).

The prefix “nano” comes from a Greek word that means something extremely small. For example, one nanometer equals to 3-5 atoms lined up in a straight line, the diameter of a human hair is about five times that of a nanoparticle, a red blood cell has a diameter ~7000 nm, while a virus has a diameter of 100 nm. Quantum physics/chemistry study atoms and molecules, as well as objects smaller than 1 nm. Physics of condensed matter explores/studies bonded atoms and molecules, i.e. objects ranging from 100 nm to infinity. Empty space is between 1-100 nm i.e. from 10 to 106 atoms per particle. Nanoparticle materials in modern physics of condensed matter are considered to be materials that consist of grains smaller than 100 nm. In the above mentioned region, neither the laws of quantum mechanics nor the laws of classical (Newtonian) physics apply. Because of the limited dimensions, there are changes in the crystalline and zone structure, the number of defects, and the size of the active area. The significance of these changes depends on the particle size. It turns out that all the changes in the characteristics have become very interesting for different applications (nanomania). Their chemical and physical characteristics are important; however, their synthesis is the most important one at this time. Some of the very complex questions/requirements in front of the synthesis are: very narrow particles size distribution without agglomeration, control of defects, specific shape and composition, etc. The classification could be based on: dimensions, phase compositions or synthesis methods (Nass et al, 2004, pp.5-10).

Based on the dimensions:

If 3D is smaller than 100 nm, there are nanoparticles, quantum dots, hollow spheres, etc.

If 2D is smaller than 100 nm, there are nanotubes, nano-fibers, nano-wires, nano-platelets, etc.

If 1D is smaller than 100 nm, there are films, coatings, multilayers, etc.

Based on the phase compositions:

One-phased solid objects are: crystallites, amorphous particles and layers, etc.

Multi-phased solid bodies (objects) are: nanocomposites, coated particles, etc.

Multi-phased systems are: colloids, aerogels, ferrofluids, etc.

Based on synthesis methods:

Reactions from a gas phase are: physical and chemical methods of deposition from a vapor phase, condensation in the atmosphere of inert gases, chemical vapor deposition, etc.

Reactions from a liquid phase are: sol-gel, method of sedimentation, hydrothermal method, etc.

Mechanical methods can be the grinding method, the method of plastic deformation, etc.

From a scientific point of view and for practical application purposes, it is of great importance that the physical characteristics of nanomaterials differ significantly from polycrystalline (bulk) materials of the same chemical composition (Table 1). In some cases, for particular physical parameters, these differences could be a few orders of magnitude. A very important characteristic of nanomaterials is that the values of physical parameters are very sensitive to the size and morphology of nanoparticles (Tadić et al, 2009, pp.839-843), (Tadić et al, 2011, pp.7639-7644), (Tadić et al, 2012, pp.28-33). Some of the examples representing significant difference in the values of some physical parameters are: the melting point, change in the unit-cell parameters, change in the magnetic and optical characteristics, conductivity of the material, etc. The surface to volume ratio is an important parameter that has an impact on new characteristics in comparison to those of bulk materials. The number of atoms on the surface (with regard to the total number of atoms) increases as the particle size gets smaller. As particles get smaller, the surface to volume ratio increases and the influence of the shell on the magnetic properties becomes more significant. For example, 3 nm size iron particles have 50% while 30 nm size iron particles have only 5% atoms on their surface that have a significant impact on their physical characteristics (Sorensen, 2001, pp.37-69).

Table 1 – Some of the common properties of nanomaterials that are significantly different from the properties of the bulk materials with the same chemical composition (Nass et al, 2004, pp.5-10).

Properties	Examples
Catalytic	Increase in surface activity of particles
Electrical	Increase in electrical conductivity of ceramic materials and magnetic nanocomposites Increase in electrical resistance in metals
Magnetic	Change of the point of magnetic phase transition Increase of coercivity Appearance of super-magnetism
Mechanical	Improvement in firmness and hardness of metals and alloys Appearance of super-elasticity
Optical	Shift in optical absorption and change in fluorescent properties Increase in quantum efficiency of semiconducting crystals

Increase of the surface to volume ratio of particles causes lower melting temperatures, lower magnetization, changes in catalytic activity, etc. A large number of atoms on the surface significantly increase "surface activity" that is very favorable for chemical reactions. However, due to increased activity, nanoparticles have tendency to form aggregates and agglomerates that could cause loss of preferred characteristics. Therefore, it is necessary to stabilize particles with some additional treatment. For example, it is possible to put particles in an adequate matrix or to coat them with a different material even though their characteristics change with this kind of surface modification. The coordination number of atoms on the surface is lower than the one for the atoms inside the particle, which would cause an increase in the surface energy. Therefore, the diffusion of atoms can take place at lower temperatures. For instance, the melting point of gold is 1063 ºC, while nanoparticles of gold with particle diameters under 5 nm have the meltingpoint of ≈ 300 ºC (Buffat & Borel, 1976, pp.2287-2298). Decreasing the particle size has a significant influence on firmness and hardness of materials (Weertman, Averback, 1996, pp.331-353).

Measurements of firmness of copper for crystallite of different sizes have shown that firmness increases as the crystallite size decreases. Firmness of the copper samples with 50 nm size crystallites is 2 times higher, while in the copper samples with 10 nm size crystallites it is 6 times higher than for the bulk. The elasticity limit of copper increases 2 times when crystallites decrease in size form 100 μm to 10 μm (Adams et al, 1989, pp.9479-9484).

One of the characteristics specific for nanomaterials is superplasticity. As opposed to bulk materials, nanomaterials have the ability to withstand the tension beyond the point of fracture. Superplasticity is explained by diffusion of atoms, i.e. moving of dislocations and sliding of the boundaries between particles.

Magnetic properties of nanoparticles

The magnetic properties of nanoparticles can be controlled with a more precise control of size and shape of nanoparticles. Namely, below a certain size, nanoparticles become mono-domain particles because that is energetically preferable and they show super-magnetic behavior that takes place above certain temperatures, so-called blocking temperatures (TB) (Chikazumi, 1999, pp.453-457).

Above blocking temperatures, magnetic moments of particles fluctuate in all directions with the help of thermal activation, similarly to paramagnetic materials, while below this temperature, magnetic moments of particles are locked in the direction of the axis of easy magnetization (Kulal et al, 2011, pp.2567-2571).

The difference from common paramagnetism is that all magnetic moments within a particle rotate coherently creating a super moment that could be of the order of a few thousand Bohr magnetos. The external field tends to align this super magnetic moment in its direction; however, thermal energy disrupts that alignment in the same way as it happens with paramagnetic materials, and that is the reason why this phenomenon was named super-magnetism.

Since the surface effect plays a significant role in investigating the magnetic properties of nanoparticle materials, the “core-shell” model has been used for their description. According to that model, a particle consists of a magnetically aligned nucleus and a non-aligned shell (Fig.1). When temperature decreases, the shell gets aligned.

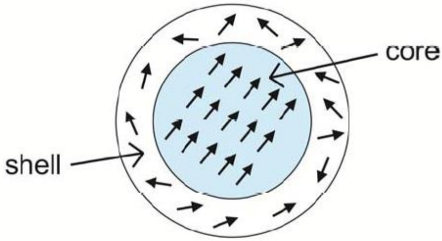


Figure1 – Schematic of the core-shell structure, I.e, the spin alignment of a spherical nanoparticle

The particle nucleus keeps the same physical properties of the bulk material, while the shell is responsible for the appearance of new properties. Namely, in the outer shell, magnetic interactions are modified due to the surface effects such as: defects, vacancies, tension, and broken chemical bonds. In addition, these effects are responsible for a decrease in the temperature of a phase change, magnetic saturation and an increase of coercivity in comparison to bulk materials.

The magnetic alignment of a nanoparticle shell is achieved by lowering its temperature (Fig.2).

For super-magnetic systems, the following specific characteristics are noticed: magnetic properties depend on the previous treatment of ZFC (zero - field cooled) and FC (field - cooled) measurements, the existence of a hysteresis loop below the block-temperature (TB) and its appearance above the TB, the appearance of a maximum during ZFC measurements (blocking temperature), and the existence of overlapping magnetization curves at various temperatures above the blocking temperature when magnetization M is shown as a function of H/T (H - magnetic field strength, T - temperature) (Sorensen, 2001, pp.37-69), (Tadić & Čitaković, 2014, pp.47-64), (Tadić & Čitaković, 2011, pp.91- 105).

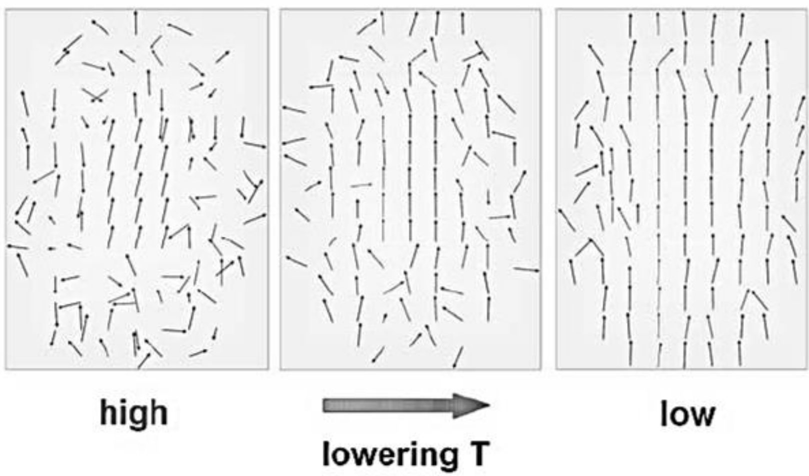


Figure 2 – Schematic of the magnetic alignment of a shell by lowering its temperature

In Figure 3, the strength of a coercive filed is shown as a function of particle size (Pelecky et al, 1996, pp.1770-1783). Above a certain critical particle size characteristic of the material DS (Table 2), a material is composed of many domains (multi-domain structure), while below the critical particle size, a material DS becomes mono-domain.

The figure shows that the coercivity increases as the particle size decreases up to a critical size for a mono-domain particle of a given DS material, beyond which it starts decreasing and, after a certain DSP value, the material becomes super-magnetic, I.e. the coercive field strength goes down to zero. In Figure 3, it could be noticed that, for very high values of the particle diameter D>> DS, the value of the coercive filed strength approaches a constant value, which is a characteristic of the material in its bulk form.

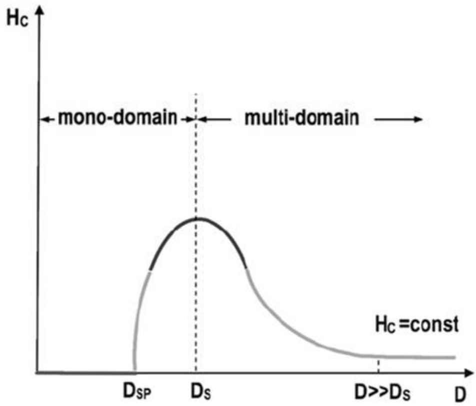


Figure 3 – Coercive field strength as a function of a nanoparticle diameter at a constant temperature. DSP - diameter below which a material shows super-paramagnetic behavior; DS - critical diameter

The critical diameter size for spherical nanoparticles depends on the material type (Table 2 shows the critical diameter values for some materials) (Sorensen, 2001, pp.37-69).

Below the critical diameter-DS, the coercive field strength decreases, according to the following functional relationship:

$$H_c = g - \frac{h}{D^{\frac{3}{2}}}$$

where *g* and *h* are constants (Kumar et al, 1994, pp.354-358).

Table 2 – Diameters of the spherical particles of some substances below which they are mono-domain

Substance	D_S (nm)
Fe	14
α-Fe_2O_3	41
Ni	55
Co	70
Fe_3O_4	128
γ-Fe_2O_3	166

Except the particle size and microstructure, the shape i.e. the elongation of the particle (ratio of the longest dimension and the shortest dimension) also affects the coercive field strength.

(Baibich et al,1986, pp.2472-2475), (Buffat et al, 1976, pp.2287- 2298), (Chikazumi, 1999, pp.453-457), (Tadić et al, 2011, pp.7639-7644), (Kulal et al, 2011, pp.2567-2571), (Pelecky et al,1996, pp.1770-1783), (Kumar et al, 1994, pp.354-358), (Zboril et al, 2002, pp.969-982), (Wang, 2000, pp.1-11), (Krill & Birringer, 1998, pp.621-640), (Audebrand et al, 1996, pp.83-87), (Huang et al, 2001, pp.1497-1505), (Gupta et al, 2011, pp.1095-1098).

For example, in the case of the Fe nanoparticle, the increased elongation of ~5 times (from 1 to 5) increases the coercive field strength for ~10 times (Krill et al, 1998, pp.621-640). In general, the coercive field strength increases as elongation increases, i.e. with the increase of the anisotropic shape (Krill & Birringer, 1998, pp.621-640).

The field of magnetic nanoparticle materials still has not been studied enough. One of the reasons is that synthesized nanoparticles have different shapes and sizes so their effects on magnetic properties could not be clearly observed. The basic aim in the process of the synthesis of nanoparticles is the creation of a desired shape and a size of particles (narrow particles size distribution). Some of the methods used for the synthesis of magnetic nanoparticle materials are: sol-gel, mechanical-chemical, glycerin-nitrate, micro-emulsion, and spray pyrolysis.

Conclusion

Nanotechnology is a growing field of research. During the last decade, interest for nanoparticle materials has been connected to their new and specific physical characteristics and possibilities for their application in all aspects of the human life. It has been noticed that there is a change in the physical characteristics (magnetic, mechanical, and optical properties, as well as in melting temperature, material conductivity, etc.) of nano-particle materials in comparison to bulk materials. In some cases, for some physical parameters, differences are up to a few orders of magnitude and can vary significantly. Nanoparticle materials are objects of intense research, because they represent a significant potential for the development of new materials that can be used/applied in various areas of science and technology. It is expected that nanoparticle materials will soon have a leading role in technology, medicine, etc. and that the production of nanoparticle based materials will be increasing in the near future.

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