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English for Students of Mathematics and Mechanics

(Part three book one)

Учебное пособие

под ред. Л. Н. Выгонской

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Учебное пособие предназначено для студентов II курса механико-математического факультета. Его цель — формирование навыков самостоятельной работы с литературой по специальности, обучение адекватному переводу, развитие навыков устной и письменной речи.

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Предлагаемое учебное пособие ориентировано на студентов II курса механико-математического факультета МГУ и представляет собой заключительную часть курса английского языка в рамках общей программы университетского обучения, разработанного кафедрой английского языка для механиков и математиков.

Концептуально данное пособие является логической компонентой разработанной стратегии обучения английскому языку математиков и механиков, когда на первых этапах они осваивают общепознавательные тексты энциклопедического характера с выделением и обозначением их лексико-грамматических особенностей, затем изучают тексты пояснительного характера, являющиеся фрагментами учебников по механике и математике на английском языке, где лексико-грамматические упражнения направлены на освоение и закрепление важнейших элементов одной из разновидностей академических текстов. Особенностью этих двух этапов является то, что содержательная составляющая текстов ясна и прозрачна для обучающихся и их главное внимание сосредоточено на формировании и накоплении лексического и грамматического потенциала для работы с более сложными формами научного жанра. Чтение, понимание, обсуждение и создание собственных текстов как устных, так и письменных, реализующихся в существующих видах научных и научно-публицистических формах на современном английском языке, является скромной целью нашего пособия.

Мы сочли необходимым во вводном уроке привлечь внимание студентов к важным по нашему мнению проблемам, связанным с изучением английского языка как иностранного, выделив при этом только три аспекта: осмысление ментальных процессов, связанных с усвоением иностранного языка; специфические особенности усвоения и пользования лексикой; важность грамматически правильной речи для процесса эффективной и адекватной коммуникации на иностранном языке.

Аутентичные тексты, подобранные для лексического, грамматического и содержательного анализа, представляют собой статьи и фрагменты статей, опубликованных в современных научных и научно-публицистических изданиях (*The Sciences, Science News, Mathematics Magazine, Scientific American, Mechanical Engineering, The Mathematical Intelligencer, American Scholar* и др.), и рассматривают проблемы, актуальные на наш взгляд для современного состояния науки и конкретно механики и математики. Поскольку специализация студентов в рамках университетской программы проходит на более поздних этапах обучения, то круг вопросов, рассматриваемых в текстах, предлагаемых для преподавания английского языка, носит скорее более общий нежели узко-специальный характер.

Подбор текстов для обучения преследовал несколько целей. Во-первых, нашим намерением было дать студентам представление о современном академическом стиле публикаций в основном периодического характера, как о наиболее распространенной форме презентации и обмена научной информацией в специфической социальной среде, где интеллектуальная деятельность превалирует.

Во-вторых, состав проблем, рассматриваемых в текстах, носит дискуссионный характер и открывает широкое поле для различных интерпретаций, мотивируя при этом живой и естественный процесс представления и обсуждения различных точек зрения и их аргументацию, что, по нашему мнению, успешно моделирует реальную коммуникативную ситуацию в интеллектуальной среде.

Важным элементом данного пособия являются так называемые «поддерживающие тексты», целью которых является расширение порога осведомленности и эрудиции у студентов. Эти тексты не предназначены для лингвистического анализа, они дают возможность студентам пользоваться ими только как источником информации, что полностью соответствует реальной ситуации в их будущей деятельности исследователей и ученых, когда текст на английском языке может представлять определенный интерес для прочтения с целью извлечения полезных сведений.

Состав лексики носит как общенаучный, так и терминологический характер. Базовая общенаучная лексика, ее освоение и накопление позволяет рассчитывать на расширение возможностей студентов адекватно воплощать мысль, суждение или аргумент в словесной форме и коррелировать свою речь в соответствии с образцами английской научной речи, представленной в виде текстов для изучения и дискуссии.

Поскольку, как показывает практика, узкоспециальная терминологическая лексика при дальнейшей специализации и чтении литературы на английском языке по конкретным научным проблемам не представляет реальной трудности, то в данном пособии мы не уделяем ей значительного внимания, хотя она выделяется и четко обозначена.

Грамматические объяснения и упражнения, предлагаемые в пособии, не носят теоретизирующего характера, а вплотную привязаны к конкретным текстам. Объектом грамматического анализа, отбора определенных грамматических явлений для овладения или закрепления и репродукции их в собственной речи являются наиболее сложные с точки зрения русскоговорящих и наиболее частотные конструкции, характерные для стиля английской научной речи.

И наконец, в пособии представлены в виде пояснений, рекомендаций и упражнений некоторые элементы теории композиции, риторики научного текста.

Выражаем искреннюю благодарность рецензентам — доктору филологических наук, профессору Е. Б. Яковлевой и доктору физико-математических наук, профессору Н. Н. Смирнову за ценные замечания, а также выпускникам механико-математического факультета МГУ Р. Ю. Рогову и А. А. Савченко за помощь, оказанную при подготовке пособия к печати.

В пособии сохранена орфография оригиналов, поэтому при написании отдельных слов наблюдается расхождение в зависимости от источника: британского или американского.

Introductory unit

In this Unit you will read and discuss three texts dealing with the English language learning problem. The first text considers the capability of our minds to learn foreign languages. The article has been published in the *Chicago Tribune* newspaper and presents the ideas of some American scientists explaining how human beings perceive second languages.

The second text is written by S. A. Hayakawa as an introduction to the book *Modern Guide to Synonyms. Choose the Right Word.* There are occasions in which we have to make correct choices among the words where one is certain to be more appropriate than the other. Nothing is so important to clear and accurate expression as the ability to distinguish between words of similar, but not identical meaning. To choose wrongly is to leave the hearer or reader with fuzzy or mistaken impression. To choose well is to give both illumination and delight.

The third text *Recognizing Good Grammar* is taken from the book *The Elements of Good Grammar* by Margaret Shertzer where she emphasizes the importance of speaking and writing grammatically to make less trouble in understanding to those whom you address your words.

Reading I

Task 1. The following list of words is dealing with processes occurring in our minds while acquiring languages and techniques employed in the investigation of human brain activity when learning languages. Study it. Consult either a dictionary or an encyclopedia to be sure you know what their meanings are.

To speak adequate fluent English, thick accent, trace of accent, to be bilingual, neurologist, capacity for learning languages, brain plasticity, to program one's brain, nerve cells concerned with major motor activity, intellectual functions, to switch from one language to another, to encode language units, mental translation process, to map brain activity, to store languages in the area of the brain, to learn the language in the environment, to encode languages into hardwired neuronal circuits, to learn and retain the information, to have a mastery of the second language, to use the direct or "mother's method" to introduce a second language.

Task 2. Read the text.

WHY JOHNNY CAN'T SPEAK A FOREIGN LANGUAGE

A family moves to the United States, none of its members able to speak English. The father, who is to begin teaching in a distinguished American college as soon as his English is adequate, struggles hard to become fluent, but can't lose his thick accent. His wife is less successful, despite taking classes in English.

But their 5-year-old son picks up English effortlessly, and without a trace of accent, on the playground, in preschool, from the baby-sitter, everywhere he goes. He will be comfortably bilingual when he enters first grade and for the rest of his life.

It has been obvious that the younger the newcomers, the easier they learn a second language.

More than three decades ago, the great Canadian neurologist Dr. Wilder Penfield pointed out that "a child's brain has a specialized capacity for learning languages — a capacity that decreases with the passage of years," because of changes in the developing brain as it loses its early plasticity.

During the first years of life, a child programs his brain with the phonemes — or basic phonetic sounds — of the language he hears all around him. Then he uses these basic units to form words and sentences and to connect with other nerve cells concerned with motor activity, thinking and other intellectual functions.

If he is casually exposed to a second language, a child learns that too, programming its basic sounds into his developing brain as he does his native tongue. He will be able to speak both languages easily, with the accent he hears around him, and to switch effortlessly from one to another.

But after the age of 10 or 12, said Penfield, a child's brain can no longer encode new basic language units in the same way. If he tries to learn a second language as a teen-ager or adult, he must do it with the language programming already in his brain, will have to use a mental translation process and will speak the second language with the accents of his native tongue.

Few educators in the United States paid any attention — either to Penfield's explanations or to the easily observable fact that small children can learn a second language effortlessly while it is much more difficult for teens and adults.

Most American school systems continue to teach foreign language primarily in high school, years after the brain has lost its ability to learn a new language easily. It's hard going for most students. And much of what they do learn is soon forgotten once school is over.

Comes now a fascinating new study that adds some neurological confirmation to the observations about language learning to which we should have been paying attention.

Using new functional magnetic resonance imaging techniques to map brain activity in healthy, bilingual adults, researchers at Memorial Sloan-Kettering Cancer Center in New York found important differences based on the age at which the second language was acquired. The results are published in the current issue of the scientific journal *Nature*.

The brains of the adults who had learned two languages as very young children stored both languages together in the same area of the brain, researchers found. Those who acquired a second language in adolescence used a second region of the brain near the first, but separate.

The research suggests that while babies and preschoolers learn the language, or languages, in their environment without apparent effort and their brain encodes them into hardwired neuronal circuits, the process is different when adolescents and adults learn a second language. They must use a different — and more difficult — process to learn and retain the information.

The occasional experiment in trying to introduce a second language in a kindergarten or elementary school has rarely worked. Too often the teacher does not have a mastery of the second language and does not use the direct or “mother’s method” so it turns out to be a waste of time. Coloring books or tapes in a second language usually don’t work either.

Educators must be smart enough to figure out how to teach children a second language easily and effectively.

Joan Beck

Task 3. Answer the following questions.

1) What is the common difficulty facing a family moving to the United States?
2) What is the condition for the father to begin teaching in a distinguished college?
3) Why can’t the father’s English be considered adequate?
4) Where does the son pick up English?
5) What is the dependence between the age and the capacity to learn foreign languages?
6) How did Dr. Wilder Penfield explain the changes in the language learning capacity occurring in human brains?
7) How does a child program his brain with his native language?
8) What happens if a child is casually exposed to a second language?

9) Does a child after the age 10 or 12 or an adult encode new basic language units in the same way? How does he or she do this?

10) Is learning of a second language for teens and adults as effortless as for a child under 10?

11) What did new functional magnetic resonance imaging techniques mapping brain activity expose?

12) Why is the process of learning the second language effortless for a child and more difficult for adolescents?

Task 4. Discuss the following.

1) In case you were not so lucky as to be casually exposed to a second language as a child you must have acquired English using some methods to learn and retain the information. What is your personal experience in the methods of learning a foreign language?

2) The child under 10 learns a second language effortlessly by the direct or "mother's method"; for adults learning a new language is going hard. Nevertheless the easily observable fact is that owing to mutual efforts of both educators and learners some positive results are available. Which methods have you found the most appropriate and effective for you personally?

3) One of the most important elements in language learning is the extension of your vocabulary. Peter Funk is a world-renowned linguist. In his *Word Power* sound edition he presents a simple technique which is supposed to dramatically increase your vocabulary and to help you express yourself more clearly and forcefully in every situation. Read his advice (in case the tape is available, listen to it) and compare your learning techniques with those recommended by Peter Funk.

WORD POWER
(extracts)

We live in a world of words. We think, learn and communicate with language. Language after all is what makes us human. Elegant and effective communication is something we all aspire to and respect. How to develop a precise and sophisticated vocabulary?

A strong quality vocabulary is a key to success and typical of successful people. Everyone should make a hobby of collecting new words. It has been proven again and again that people with strong vocabularies have more confidence, have greater success in school and business, in their professions and in their social lives. A wider vocabulary enriches your personal life, you will become a more interesting person. You will have a greater enjoyment of movies, books and theatre. You will also find that your conversation will improve and you will be able to communicate better. You will be able to go to lectures, read more books and understand more complicated ideas. Let's find out a few amazing things about our language.

English is the universal language in the world. At least 600 000 000 speak it as a second language.

We have three types of vocabulary as with respect to size. Our largest is our **recognition**. College graduates have probably about 60 000 words they would recognize, words they will read or hear. Then comes a **writing** vocabulary in which we have more time to think and plan what we are going to say. And finally our **speaking** vocabulary is the smallest. However this does not mean in speaking just to keep to simple words.

We need our vocabulary to adequately express our ideas. We now have over million words, but the heart of the English language is about 10 000 words. The rest, many of which you recognize in reading or hearing, often are useful in a specialized sense that is in technical, descriptive or limited in scope.

The techniques to learn new words are useful in developing a technical vocabulary for a specific field. For example if you have recently joined the computer revolution you know there is a whole new vocabulary that goes along with the new technology. An important component of mastering the technology is mastering the vocabulary that describes it. In fact one quick way to make an easy study in a technical area that is new to you is to study the glossary of a textbook on a subject first. Then when you start reading the textbook you will already be familiar with the terminology it uses to explain new concepts.

* * *

Here are some suggestions about how to learn new information and retain it:

Most important: use the information. When you hear a new word use it the same day in conversation or in writing. Use builds long-term memory, chemical path-ways in brain. Learning anything, piano, tennis or whatever, takes repetition. Now get it to habit of practice, spending a few minutes a day to learn is better than spending an hour once a week. Take it easy. If you try to learn fifty words in a day you will get discouraged almost immediately. Go slowly but consistently. Do one or two words a day. At that rate skipping weekends you will be increasing your vocabulary by twenty to forty important words a month giving you nearly 500 new words a year. Most adults only have a handful, if that.

Associate new information both with other words and with visual images. For example, you read a word that is new to you: "circumspect". Studying the prefix and root you see that "circum" — the prefix means "around" and "spect" — the root means "to see". We have two sections here — "circum" and "spect". Try associating these two sections with a word you know, for example, you might know the word "circumference" — the distance around a circle, from high school geometry and what the people use to help them to see — "spectacles". Now associate this information with a visual image. In fact "circumspect" means to be conscious, watchful, literally to look around before taking actions. Use humorous exaggerations to hold a memory emplaced.

So, to learn new information that really stays with you make sure to

1) **use the information repeatedly,**

2) develop consistent study habits,
3) associate the new information with facts you already know,
4) try to actively visualize the new concepts in an imaginative way.

How to teach yourself new words to expand your vocabulary? Increasing your vocabulary is one of the fastest and easiest ways to become smarter. When you learn a new word you are actually giving your mind a new concept, you create new pathways in your brain linking the word with other concepts and it is exciting to know that your brain can grow your entire life.

Note new words in conversations or in reading. Note the words that are new to you. If you are reading a book, magazine or newspaper and don't have a dictionary handy, circle the word. You can check on it later, at the same time try to figure it out within the context of the sentence. Chances are that you could make a good guess. Write it down. Keep some three by five index cards handy. Write down the words that you come across one on each card. Later with the help of a good dictionary write down the pronunciation, the origin including the prefixes and the roots and the meaning of the word. Write down a sentence in which the word appears and keep these words in places where you will see them: your refrigerator, bathroom, mirror et cetera. Carry a few around each day in your pocket to look at in transport, waiting for an elevator, wherever if you have a few seconds. By writing down these words you are building your personal dictionary.

Use mnemonic devices. Mnemonic has to do with systems of memory techniques. Use the memory tricks, you can invent, your own visualization or association systems. Use them that is the real secret. Put these new words to work in conversation and writing. The more you use new vocabulary the more it stays in your memory ready to pop up when you need it.

Revision

1. Write new words down on flash cards for study.

2. **Become familiar with the building blocks of words — prefixes, roots and suffixes.**

3. **Use mnemonic devices and visualization techniques.**

4. **Actively make use of your new vocabulary.**

Reading II

Task 5. The following list of words is dealing with an analysis of the vocabulary, synonyms and word meanings in the English language. Study it, your teacher will help you. Consult either a dictionary or an encyclopedia to be sure you know what their meanings are.

Vocabulary, synonyms, language, to incorporate words from other languages, to borrow a word, to double a vocabulary, words reflecting a higher standard of living, words reflecting more complex social life and organization, pre-existing Anglo-Saxon vocabulary, enormous expansion of classical learning in the Renaissance, influx of words of Latin and Greek origin, to relegate words to special technical contexts, to expand the vocabulary, to add vastly to the vocabulary, to gain recognition and prestige, terminology for, to place a group of synonyms at service, no exact equivalencies of meaning, to uphold a position, range of contexts, interchangeable, to imply different relationship among parties, locution, formality of discourse.

Task 6. Read the text.

CHOOSE THE RIGHT WORD

English has the largest vocabulary and the most synonyms of any language in the world. This reachness is due to the fact that the English language has grown over the centuries by constantly incorporating words from other languages. Even before the Norman Conquest, the Anglo-Saxon vocabulary included words borrowed from Latin *(street, mile)*, Greek *(priest, bishop)* and Scandinavian *(law, fellow, egg).* After the Norman Conquest, the English vocabulary was virtually doubled by the addition of French words, especially those reflecting a higher standard of living and a more complex social life: for example, words connected with food *(sugar, boil, fry, roast)*, clothing *(garment, robe, mantle)*, law *(legacy)* and social rank and organization *(prince, duke, mayor).*

While much of the new French vocabulary described new ideas and activities, much of it duplicated the pre-existing Anglo-Saxon vocabulary, giving the writer or speaker a choice of synonyms: *cure* (French) or *heal* (Anglo-Saxon), *table* or *board*, *labor* or *work*, *mirror* or *glass*, *assemble* or *meet*, *power* or *might.*

With the enormous expansion of classical learning in the Renaissance, there was a great influx of words of Latin and Greek origin into the language, dictated by the demands of an enriched intellectual and cultural life. Also, the larger world discovered through travel and exploration (especially in the Elizabethan period) was a great stimulus to culture and language. Many words of classical origin introduced into the language during the Renaissance became permanent additions, but most were soon forgotten or were relegated to special technical contexts.

The adventures of English-speaking people as they traded and fought and travelled around the world in modern times — in Europe, North America, India, Australia, Africa — also expanded the vocabulary.

Furthermore, the United States, as a separate nation with its own life and character and institutions, added vastly to the English vocabulary, beginning in Colonial times. With the rise of the United States to the position of world influence in politics, science, industry, trade and the popular arts, American words and phrases have gained recognition and prestige everywhere. *Ice cream, jeep* and *rock-and-roll* are internationally known terms. The American terminology for many things exists side by side with the British terminology, placing another whole group of synonyms at our service: *help* (American) and *servant* (British), *sidewalk* and *pavement*, *billboard* and *hoarding*, *movies* and *flicks*, *druggist* and *chemist*, *water-heater* and *geyser*, *checkers* and *draughts*, *soft drinks* and *mineral waters*, and so on through an almost interminable list.

Synonyms in English are therefore of many kinds. It can be argued that there really are no exact synonyms — no exact equivalences of meaning. Such a position can be upheld if by “meaning” we refer to the total range of contexts in which a word may be used. Certainly there are no two words that are interchangeable in all the contexts in which either might appear.

Some groups of words describe the same actions, but imply different relationships among parties concerned. We *accompany* our equals; we *attend* or *follow* those to whom we are subordinate; we *conduct* those who need guidance; *escort* those who need protection, and *chaperone* those who need supervision; merchant ships are *convoyed* in time of war. Some differences in locution reveal differences in the degree of formality of the occasions described: *a luncheon* as distinguished from *a lunch*. Sometimes different locutions reveal differences not in the situations described but in the formality of discourse about them: *He went to bed*, for instance, as compared to *He hit the sack*.

Words change in meaning according to time and place and circumstance. Yet, with all the changes that go on both in language and in the world described by language, there are remarkable elements of stability in a vocabulary with as rich a literary and cultural history as English. The study of synonyms will help to come closer to saying what one really wants to say.

S. A. Hayakawa

Task 7. Answer the following questions.

1) Why is the English language so rich in words and synonyms?
2) When was the English vocabulary virtually doubled and what aspects of vocabulary were affected mostly?
3) What are the examples of pre-existing Anglo-Saxon vocabulary duplicated by the new French one?
4) What did enormous expansion of classical learning in the Renaissance result in?
5) What dictated a great influx of words of Latin and Greek origin into English?

6) What happened to many words of classical origin introduced into the language during the Renaissance?
7) Where did English-speaking people trade, fight and travel around the world in modern times?
8) How did the United States as a separate nation add to the English vocabulary?
9) What is "meaning"? What does the author refer to by "meaning"?
10) What groups of synonyms are given in the text and what do they differ in?

Task 8. LANGUAGE and VOCABULARY are the two words used frequently in the text. They can be considered as synonyms when they are used as meaning oral or written expression. But they are not interchangeable in all contexts as far as they have difference in meanings. Read a fragment from *A Modern Guide to Synonyms* and put either LANGUAGE or VOCABULARY into the gaps. (You should use the word "language" 10 and "vocabulary" 4 times.)

__________, in one sense, denotes all sounds spoken and combined into words and sentences that human beings use for the communication of ideas or emotions. In a more limited sense, __________refers to those words and combinations that have been systematized and confirmed by usage among members of a certain nation, people, or race at a given period: the French __________. In its widest sense, __________signifies expression of thought by any means: the __________of eyes, the __________of flowers. The words or expressions used in a specific business, science, etc. are also referred to as __________: the __________of mathematics. __________is the sum of words used or understood by a certain person, making up a particular __________, or employed in some business, science, etc.: the immeasurable contribution of Greek to the English __________; a lawyer's __________. It refers, by extension, to a person's preference in the area of __________: Hardy's __________was largely Anglo-Saxon.

Task 9. Below are two columns of words. In the first one are the words taken from the text, in the second column are the words with synonymous meaning. Match a word from the first column with the one in the second column to have a pair of synonyms.

politics	commerce
science	systematized knowledge
industry	good's production
trade	diplomacy

Task 10. Consider the following group of synonyms:
plain, pampas, steppe, prairie, savannah, tundra.

They refer to geographical variants of the same kind of thing. Identify their origin. Choose from the following: (French), (Russian), (Russian from Lappish), (French voyager), (Spanish), (Spanish from South American Indian).

Task 11. Consider the following group of synonyms: **teach, educate, indoctrinate, instruct, school, tutor.** They differ from each other principally in degrees of abstraction: **teach** is certainly the most general word of this group, while the others are more specialized in application. The following text will give you an idea how to differentiate the usage of these words in various contexts.

"These words refer to the process by which knowledge is imparted to students. **Teach,** suggests a guided process of assigned work, discipline, directed study and the presentation of examples: *teaching* her pupils the letters of alphabet. It also refers to this work thought of as a profession: *teaching* in the freshman English program. **Educate** is more formal than *teach* and is less specific, referring in a more general way to a long-range, wide-sale academic process: *educating* the coming generation by means of newly discovered methods. Sometimes the word suggests the accomplishing of greater results than *teach*: schools that *teach* but simply fail to *educate* their students.

School suggests an especially thorough process: *schooling* the class in the essentials of arithmetic. **Instruct** is more formal and is mostly restricted to the specific situation of guided training or to the imparting of information or commands: a manual *instructing* buyer on the installation of air conditioner.

Tutor refers to a special one-to-one relationship between teacher and student: English colleges where each student is *tutored* by a don. **Indoctrinate** suggests the inculcation of propaganda or prejudices rather than unbiased knowledge: parents who *indoctrinate* their children with race hatred."

Write 12 sentences of your own using each word in two sentences. Find an appropriate context for each word.

Task 12. Read the following text. It has been taken from *Roget's Thesaurus of the English Language in Dictionary form.*

A WORD OF CAUTION

Synonyms are good servants but bad masters; therefore select them with care. Theoretically, a synonym is a word identical in meaning with another of the same language. If this were literally true, the choice of a substitute word would be child's play. It is doubtful, however, whether any two words are identical in all their senses and connotations; which is another way of saying that there are no perfect synonyms. For this reason, synonyms should not be taken at random. ... great care must be exercised by the writer who wishes to fit the exact word to his thought.

Another point to remember is that words which are broadly synonymous with one particular entry (dictionary entry is meant here) are not necessarily interchangeable with one another. Suppose you want a synonym for the word "raw". You turn to the letter R and find the entry (in *Roget's Thesaurus*) thus recorded:

> **raw,** adj. chilly, piercing, cutting; immature, crude, unripe, uncooked, unprepared; excoriated, galled, chafed; unskilled, untrained, green, inexperienced; wind-swept, exposed, bleak.

Here are five distinct senses of the word "raw". Thus, while *uncooked* may be substituted for *raw* in referring to vegetables, we should not employ it in reference to silk or recruits, much less to describe the weather or the state of an open wound.

Question: Does the author of the text teach, educate, indoctrinate, instruct, train or tutor how careful one should be dealing with words and their meanings while choosing a synonym?

Task 13. Of great importance for everyone who learns foreign languages is to distinguish between a **word** and its **meaning.** When we use a word as the name for its meaning we are actually using it in a normal way. Words are names for their meanings. Indeed one characteristic of "primitive" thinking is the confusion of words and their meanings. We must just bear in mind that many words have more than one meaning. Words that share the same meaning (though not necessarily the same style) are synonyms. So synonyms are words that have the same meaning. Synonyms make difference between words and their meanings.

Look at the three words which are certainly familiar to you: **circle, line, number.** How many meanings does each word have? Compare your answers with the dictionary articles for each entry taken from *Webster's Dictionary.*

circle n. a plane figure bounded by a single curved line called its circumference, every point of which is equally distant from a point within called the center; the curved line that bounds such a figure, a circumference; a round body; a sphere; an orb; a ring; the company associated with a person; a society group; club or group, esp. literary; a never ending series.

line n. a rope, wire or string; a slender cord; a thread-like mark; an extended stroke; *(Math.* that which has one dimension, length, but no breadth or thickness; a curve connecting points which have a common significance (as the Equator, isotherm, isobars, contours, etc.); a boundary, a row or continued series; progeny; a verse; a short letter or note; a course of conduct, thought, or policy; a trend; a department; a trade, business or profession; a system of buses, trains, or passenger aircraft under one management; a railway track; a formation of naval vessels; the regular infantry of an army; harmony; graceful cut (as of a costume, dress); a path; a thin crease; parts of a play memorized by an actor or actress; military fieldworks.

number n. a word used to indicate how great any quantity is when compared with the unit quantity, one; a sum or aggregate of quantities; a collection of things; an assembly; a single issue of a publication; a piece of music; *(Gram.)* classification of words as to singular or plural; *pl.* metrical feet or verse; rhythm.

Discussion of facts, ideas, and concepts

Task 14. Discuss the following in the class.

It is inefficient to have two words expressing the same meaning. Why do you think English has synonyms? Why do you think terminology avoids synonyms?

Reading III

Task 15. The list of words given below is dealing with importance of good grammar for anyone who wants to speak or write effectively. Study it. Consult either a dictionary or an encyclopedia to be sure you know their meanings.

To prefer, to avoid, effective speech and writing, to state rules, rules governing the words we use, to achieve clarity of expression, to present ideas forcefully, to confuse the words, language suited to our purpose, crude choice of words, informal speech, colloquial expression, to use English correctly and gracefully, to be accustomed to speaking grammatically, to recognize correct usage, good habits of speech, academic texts, compositon.

Task 16. Read the text.

RECOGNIZING GOOD GRAMMAR

Grammar may be defined as a system of rules for the use of language, or as a study of what is preferred and what is to be avoided in effective speech and writing.

We all speak and write whether or not we are able to state rules governing the words we use. To be effective we must achieve clarity of expression. We need to know how to present ideas forcefully, without confusion or unnecessary words, by choosing language suited to our purpose.

A speaker may say, "It's me. I ain't the one that come first, out I'm gonna speak for all us boys." The intent is clear, but the choice of words is crude. While informal speech commonly uses colloquial expressions, few people wish to appear illiterate in their speaking or writing.

In order to use English correctly and gracefully, it is necessary to recognize and to practice using good grammar. Listening to speakers who are accustomed to speaking grammatically helps to train the ear to recognize correct usage. Simple, idiomatic English is desirable for both writing and speaking, but it is not effortless.

Good habits of speech will improve one's writing, but the best training may be to read examples of effective writing. Whether the subject is a news report, a humorous anecdote, a comment on today's events, a description of an exciting happening, a romantic novel or an academic text — any of these kinds of writing can be satisfying to read and instructive to study.

The Elements of Good Grammar by M. Shertzer

Task 17. Answer the following questions.

1) How may grammar be defined?
2) Are all who speak or write able to state rules governing the words we use?
3) What must anyone achieve to be an effective speaker or writer?
4) What does it mean "to present ideas forcefully"?
5) Are there many people who wish to appear illiterate? Are you?
6) What makes people think of a person as being illiterate?
7) What is necessary to use English correctly?
8) How can one train the ear to recognize correct usage?

9) What is the best training for speaking and writing grammatically?

10) What kind of texts are considered to be satisfying to read and instructive to study?

Task 18. Coming back to the third question consider different ways of expressing the same idea. The following sentences are the illustration of multiple possibilities of a speaker or writer in taking advantage of the resources of the English language. These sentences are an example of experimenting with language structures in finding various approaches to the same pair of ideas. Study them. (The examples are taken from the book *A Practical Rhetoric* by John Hurley.)

1. Grant was a great general, but he was not a great tactician.
2. Grant was a great general, although he was not a great tactician.
3. Grant was a great general; however, he was not a great tactician.
4. Grant was a great general; he was not a great tactician.
5. Even though Grant was a great general, he was not a great tactician.
6. Grant was not a great tactician even though he was a great general.
7. Though he was a great general, Grant was not a great tactician.
8. Grant was not a great tactician, though he was a great general.
9. Although he was not a great tactician, Grant was a great general.

10. Though not a great tactician, Grant was a great general. (This contains an elliptical clause. Subject and predicate are absent from the subordinate clause.)

11. Grant was a great general, not a great tactician, however.

12. However great he was as general, Grant was not a great tactician.

13. Grant was a great general; nevertheless, he was not a great tactician.

14. Grant's greatness as a general was marred by his shortcoming as a tactician.

15. Grant was a great general in spite of his shortcomings as a tactician.

16. As a general Grant was great, but as a tactician, he was not.

17. Despite his shortcomings as a tactician, Grant was a great general.

18. His shortcomings as a tactician did not keep Grant from becoming a great general.

19. As a general, Grant was great; as a tactician, he was not great.

20. To be a great general, as Grant was, is not to be a great tactician, as he was not.

21. Being weak as a tactician cost Grant some battles, but being strong as a general won him the war.

22. Whatever weakness he possessed as a tactician did not keep Grant from becoming a great general.

23. That he was not a great tactician does not mean that Grant was not a great general.

24. Compensating for his weakness as a tactician is part of Grant's strength as a great general.

25. Part of Grant's greatness as a general is his recognizing his weakness as a tactician.

26. Being a lesser tactician than Lee did not keep Grant from being a greater general.

27. Overcoming his weakness as a tactician, Grant went on to become a great general.

Take 5 pairs of ideas from the subjects you are studying currently. Try all the possibilities of wording them that come to mind. Develop the habit of writing complicated sentences. Write them down and discuss in the class.

Task 19. The text *Recognizing Good Grammar* states that not to appear illiterate in speaking one should use English correctly and gracefully. But speaking grammatically is not effortless. Some people have bad habits of speech.

Read the following fragment. It is taken from the book *A Time to Kill* by a popular contemporary author John Grisham. The dialogue in the fragment is informal. Rewrite it, correct all the violations of normal grammatical rules in the text and make all short forms full.

(Two men Carl Lee and Leroy have got into trouble and are expecting their trials. In the fragment they are talking about Jake — the lawyer who had been Carl Lee's lawyer but later was fired. Now Jake works for Leroy. Carl Lee hired another lawyer who seems to be crook and does not care much about his client. Leroy comes after his meeting with Jake.)

"Where you been?" Carl Lee asked.

"Talkin' to my lawyer."

"Jake?"

"Yeah."

"You look worried," Carl Lee said. "Bad news about your case?"

"Naw. Just can't make my bail. Jake says it'll be a few days."

"Jake talk about me?"

"Naw. Not much."

"Not much? What'd he say?"

"Just ask how you was."

"That all?"

"Yeah."

"He's not mad at me?"

"Naw. He might be worried about you, but I don't think he's mad."

"Why's he worried about me?"

"I don't know," Leroy answered.

"Come on, Leroy. You know somethin' you ain't tellin'. What'd Jake say about me?"

"Jake said I can't tell you what we talk about. He says it's confidential. You wouldn't want your lawyer repeatin' what y'll talk about, would you?"

"I ain't seen my lawyer."

"You had a good lawyer till you fired him."

"I gotta good one now."

"How do you know? You ain't ever met him. He's too busy to come talk to you, and if he's that busy, he ain't got time to work on your case."

"How do you know about him?"

"I asked Jake."

"Yeah. What'd he say?'

Leroy was silent.

"I wanna know what he said,"

"He's crook," Leroy said. "He's a big-shot crook who'll sell you out. He don't care about you or your case. He just wants the publicity. He hasn't touched your case all week. Jake knows, he checked in the courthouse this afternoon. Not a sign of Mr. Big Shot."

"You're crazy, Leroy."

"Okay, I'm crazy. Wait and see how hard he works on your case."

"What makes you such an expert?"

"You asked me and I'm tellin' you. You know what them rednecks on the jury'll say when they see your new lawyer?" Leroy asked.

"What?"

"They're gonna think this poor nigger is guilty, and he's sold his soul to hire the biggest crook in Memphis to tell us he ain't guilty. They're gonna fry you, Carl Lee."

Unit 1

You are going to read a journal article entitled *POWER WHERE SUN MEETS SEA* published in *Mechanical Engineering*. At first glance this article doesn't seem to have much to do with solution of problems in mathematics or mechanics. It is certain to deal with engineering but on closer inspection one can understand that both mathematics and mechanics are basic instruments able to give a positive solution of the engineering problem.

Reading

Task 1.

a) Consider the title, the sub-title and the key words and try to formulate the main idea of the text:
energy, energy conversion, power, sun, water temperature differential, pump, electricity, plant, power turbine, vacuum chamber, efficiency, pressure, generate, concrete, condense, technology.

b) Write down three questions that you might expect to be answered by reading this text. Compare your questions with those of your partners and discuss them.

Task 2. Skim the text. Complete either of the following statements:
I was right the text deals with the problems ...
I was not right the text doesn't deal with the problem ...

POWER WHERE SUN MEETS SEA
A thermal conversion project taps into the ocean's stored energy

Each day, tropical oceans absorb the energy equivalent of 250 billion barrels of oil. The Ocean Thermal Energy Conversion (OTEC) Project in Kailua-Kona, Hawaii, taps into this energy for what may be a clean source of power for future generations.

While the sun warms the surface of tropical waters to 80°F, at depths of 5000 feet temperatures are near freezing. This temperature differential is key to the open-cycle OTEC process, in which warm surface water is pumped to a vacuum chamber to produce steam that drives a turbine. At the same time, a heat exchanger uses cold water pumped from the depths to condense spent steam into drinkable water. OTEC, therefore, desalinates water as well as produces electricity.

In 1930 Georges Claude, a French engineer who invented neon lighting, designed the first known OTEC plant, off the coast of Cuba. The plant, which was mounted on a barge, was designed similar to the one in Hawaii. The floating plant generated 22 kilowatts, but it required more electricity than that to operate. The challenge, then as now, was how to extract the thermal energy stored in tropical seas to produce electricity economically.

The OTEC Project in Kailua-Kona, designed by the National Renewable Energy Laboratory and operated by the Natural Energy Laboratory of Hawaii Authority, came on-line in March 1993. The structure is built on a lava flow at Keahole Point, about 500 feet off the western coast of the big island of Hawaii and 13 feet above sea level.

The OTEC building houses the heat exchanger and power turbine, and serves as the vacuum chamber for the entire process. "Making the vacuum chamber of concrete, a fairly porous material, was one of the greatest design challenges facing us," said Desikan Bharathan, leader of the OTEC design team. The OTEC engineers solved the problem by using a dense mixture of reinforced, post-tensioned concrete, which made the building airtight and the structure more resistant to corrosive seawater.

The OTEC building is a 16-sided polygon, 25 feet in diameter and 31 feet tall. The walls are I foot thick, except at the base of the vacuum chamber, where they are twice as thick. The base of the vacuum chamber has inlets and outlets for warm and cold water, a port for inducing a vacuum, a hatch for personnel, and many smaller instrument and observation ports.

A high-density polyethylene pipe, 200 feet long and 36 inches in diameter, brings 9000 gallons of warm surface water per minute to a point 50 feet from the plant. Here, a series of fiber-reinforced plastic lines direct the water into the OTEC vacuum chamber. Six high-speed centrifugal vacuum compressors (more than 20,000 RPM) provide high vacuum efficiency. The vacuum-exhaust system is rated at 40 horsepower.

The vacuum-compressor train reduces the pressure of the seawater to about 3 percent of the atmosphere. This low pressure causes the water to boil at 72°F, which in turn produces steam. The low-temperature steam is directed to a steam turbine, which generates up to 270 kilowatts of electricity.

A 1-mile-long, 40-inch-diameter, high-density polyethylene pipe brings cold water from a depth of 2200 feet to the juncture 50 feet offshore of the plant. Several centrifugal pumps draw a total of 13,500 gallons of water per minute with a temperature of 48°F from the depths of the Pacific Ocean. Of that amount, 6500 gallons per minute is directed to the OTEC project and the rest to other projcects.

The cold water for the OTEC plant is piped to a direct-contact condenser inside the vacuum chamber. This centrally located, cylindrical unit contains structured packings similar to those used in industrial cooling towers. Most of the spent steam from the OTEC turbine is directed to this condenser, where it contacts the cold seawater. The process causes the steam to condense and mix with the seawater before being discharged back into the ocean. A small portion of the spent turbine steam is directed to a plate-fin condenser, which produces 6 gallons per minute of desalinated water that is used to irrigate plants.

In September 1994, the Kailua-Kona station set a world record for OTEC-derived electricity, generating 270 kilowatts while using 151 kilowatts to operate its pumps, according to Bharathan. "We proved it is possible to produce net power by using OTEC technology, which is the first step in commercializing the process," he said. The next step is reducing the technology's cost by using less expensive materials. The OTEC team, for example, is studying the use of flexible hose and a bottom-mounted pump to bring cold water from the ocean depths.

OTEC's desalination and power-generation capabilities make the technology ideal for many island nations, such as those in the Caribbean Sea where potable water must be imported. In addition, the spent cold seawater can be used to cool buildings. OTEC's cold water is rich in nutrients useful for aquatic farming of Nori seaweed, abalone, and lobster. India and Taiwan also have expressed interest in OTEC technology.

MICHAEL VALENTI

Vocabulary

Task 3. Below are some words taken from the text. Try to guess their meaning by thinking about the context in which they are found. In each case choose one of the three answers which you think best expresses the meaning.

design — (line 14)

(a) to learn or to develop something;
(b) to draw the outline of something, to plan a detailed final draft;
(c) to pump water into a chamber.

operate — (line 17)

(a) to make a mechanism function;
(b) to make an object ready for use;

(c) to examine closely.

challenge — (line 18)

(a) a wing or a structure remembering wing;
(b) an invitation to a contest; a calling in question, a problem waiting for alternative efficient solutions;
(c) space between two points or limits.

induce — (line 38)

(a) to give origin to, initiate;
(b) to cause a particular physical condition;
(c) to change inaction into action.

train — (line 47)

(a) sequence of devices, mechanisms, a series;
(b) line of carriages and an engine on a railway;
(c) a mark left by anything.

juncture — (line 53)

(a) a place where two things are joined or united;
(b) a critical time or state of affairs in the life of a person or the history of a country;
(c) act of dividing.

capability — (line 78)

(a) the character in a thing arising from the possession of the qualities necessary to the performance of a certain kind of work;
(b) a material that is not able to be penetrated;
(c) electrically charged atom.

Task 4. Consider the list of the words (1); match each of the following words with the one given in the list (2) below:
(1) airtight — ... ; waterproof — ... ; leakproof — ... ;
fireproof — ... ; ecologically safe — ... ; shell-proof — ... ;
(2) battery, fabric, technology, wall, chamber, raincoat.

Task 5. Consider the following list of the words:
oil *concrete* *water* *reinforced concrete.*

All these words can be grouped under the name *substance*. Speak about each substance in the list keeping up to the following order:

1. What is it? Try to give a definition.

   Definitions can be written in many ways. The most common form of *formal definition* contains three elements:

(1)		(2)		(3)
name of the term being defined	+ verb +	class to which it belongs	+ who/which that/where +	special features

   A triangle(1) is a geometric(2) figure which has(3) three straight sides and three angles.

2. What are the spheres of its application?

3. What is it applied for?

You can find useful information in the text. Consult it.

4. Find in the text at least 5 mathematical terms and define them.

Grammar notes and grammar tasks

Our study of some grammar areas here and on aims at emphasizing some grammatical structures typical of the academic style that are specific for English and very often do not have an equivalent in Russian. Mostly we will concentrate your attention on improving style, on developing various avenues of expression, on providing the variety of expression. We will try to give a meaningful study of grammar structures. You are recommended to consult *Грамматический справочник.* Л. Н. Выгонская, Е. И. Миндели. Изд-во механико-математического факультета МГУ, 1998.

Task 6. Below are three lists of the words taken from the text, read them and think about their meaning and form.

List 1

Temperature differential; surface water; vacuum chamber; heat exchanger; lava flow; sea level; OTEC building; power turbine; design challenge; design team; OTEC engineers; observation port; vacuum condenser; vacuum efficiency; horsepower; seawater; steam turbine; turbine steam; world record; net power; ocean depth; island nations.

List 2

Equivalent of 250 billion barrels of oil; source of power; surface of tropical water; depth of 500 feet; laboratory of Hawaii Authority; western coast of the big island; big island of Hawaii; chamber of concrete; leader of design team; mixture of concrete; base of the vacuum chamber; gallons of water; a series of fiber-reinforced plastic lines; pressure of the seawater; 3 percent of the atmosphere; a small portion of the spent turbine steam; use of flexible hose.

List 3

Ocean Thermal Energy Conversion (OTEC) Project; open-cycle OTEC process; OTEC design team; a high-density polyethylene pipe; OTEC vacuum chamber; vacuum-exhaust system; vacuum-compressor train; a 1-mile-long, 40-inch-diameter, high-density polyethylene pipe; plate-fin condenser; OTEC's desalination and power-generation capabilities.

Grammar notes 1

We put two or more nouns together to describe a common thing or a concept that needs a special name. Some are written separately (chess board), some are written with hyphen (writing-desk), some are written as one word (seawater). There are a large number of possible meanings that can be expressed:

1 place — (a newspaper article)
2 time — (afternoon tea)
3 material — (iron bridge)
4 functional relationship (steam engine)
5 direct object (a pipe test)
6 complement (a woman driver)
7 part (seaside, river bank)
8 measurement (1-foot thick side), (five-liter chamber)

A In all the structures given in *List 1* only the second word is used like a noun, the first is similar to an adjective. If two nouns are joined in an expression "a b" we can usually say "b" does something to "a", or "b" produces "a", or "b" goes to "a", or "b" is in / from / for / with / about / etc. "a".

Example:
a bookcase (a case that holds books)
an oil well (a well that produces oil)
a sheep dog (a dog that looks after sheep)
a Moscow man (a man from Moscow)
a garden chair (a chair in or for the garden)
an airport bus (a bus that goes to the airport)

Task 7. State a relationship in "noun as adjective" structures given in *List 1.*

Example:
temperature differential — the differential between the temperatures of surface water and water at depth of 5000 feet.

B The "noun as adjective" structures are used mostly to describe common, well known kinds of things or concepts. In "road sign" we do not think separately of the two ideas "road" and "sign", we think of a particular kind of a metal plate with writing or picture on it. It is like a single word.

In "signs of damage" two ideas are still separate and here we prefer to use a prepositional structure. Compare: mountain top, the top of the loudspeaker.

Task 8. Consider *List 2.* Compare "noun as adjective" structures in *List 1* with prepositional structures in *List 2.* Take any text in English. It can be either an article in a newspaper or a fragment from a journal or a book. Find 10 examples for both structures. Arrange them in two columns.

C More than two nouns can be joined in "noun as adjective" structure. Two, three and more nouns can be used as adjectives. For example: oil production cost, road accident research center, headline — "Death drug research center spy drama". Expressions like these can be understood by reading them backwards. It is about drama concerning a spy in a center for research into drug that causes death. The nouns in such structures can be modified by adjectives, participles, adverbs.

Task 9. Read the strings of nouns and modifiers in *List 3* backwards, understand the meaning.

Example:

1. Earthquake waves theory — theory dealing with the waves produced during earthquakes.

2. X-ray photographs interpretation study — the study of the interpretation of the photographs made by means of the rays discovered by Roentgen.

Task 10. Below are three sentences taken from the text. In all three cases you will find modal verbs:

1. The Project taps into this energy for what *may* be a clean source of power for future generations.
2. OTEC's desalination and power-generation capabilities make the technology ideal for many island nations such as those in the Caribbean Sea where potable water *must* be imported.
3. In addition, the spent cold seawater *can* be used to cool buildings.

Grammar notes 2

May expresses uncertainty, doubt. E.g. I may come tomorrow if I have time.
May expresses probability, suggests a free choice between two or more alternatives. E.g. The water may be warm enough to swim.
May is used when asking for a permission. E.g. May I speak for more than 20 minutes.
Must expresses obligation, absolute necessity with no freedom of choice. E.g. In order to graduate you must pass the exams.
Must expresses certainty, strong likelihood. E.g. You have worked hard, you must be tired.
Must expresses prohibition. E.g. You mustn't read in bed. It's bad for your eyes.
Can expresses doubt, incredulity. E.g. Scotland can't be very warm in September!
Can expresses ability, resulting from knowledge, from physical strength, from circumstances. E.g. He can lift heavy weights. He can borrow my pen.
Can is used for asking permission, giving or denying permission. E.g. Can I see Mr. N? Is he in? No, you can't. He is being examined by the professor.

Task 11. Identify the meaning of *may, must, can* in the sentences from Task 10. To review the grammar area consult your grammar book, pp. 29–31.

Task 12. Below are some sentences from the text. Read them paying attention to the italicized words.

1. At depths of 5000 feet temperatures are near *freezing.*

2. *Making* the vacuum chamber of concrete ... was one of the greatest design challenges *facing* us.

3. The OTEC engineers solved the problem by *using* a dense mixture of reinforced, post-tensioned concrete.

4. The base of the vacuum chamber has ... a port for *inducing* a vacuum.

5. This ... unit contains structured *packings* similar to those used in industrial *cooling* towers.

6. The process causes the steam to condense and mix with the seawater before *being discharged* back to the ocean.

7. In September 1994, the ... station set a world record ... *generating* 270 kw while *using* 151 kw to operate its pumps.

8. We proved it is possible to produce net power by *using* OTEC technology which is the first step in *commercializing* the process.

9. The next step is *reducing* the technology's cost by *using* less expensive materials.

10. OTEC's cold water is rich in nutrients useful for aquatic *farming*.

Grammar notes 3

The form of the verb ending in *-ing* is sometimes used more like a verb or adjective or more like a noun. Trace the transition from dynamics to statics in forms.

to write	*writing*	*writing*	*the writing*
action	being involved in the process of ...	the process of	name of the action

Example:

being involved in the process of ...	*Writing* a letter to his mother he realized how long he has not seen her. The man *writing* a letter to his mother realized how long he hasn't seen her.
the process of ...	*Writing* is not as simple thing as it seems to be. I like *writing* letters to my friends. You can improve your English by *writing* a composition a day.
name of the action	Your *writing* of a composition is very poor.

Task 13. Classify each *ing*-form in the sentences from Task 12 according to the scheme presented above.

Task 14. Take any text in English. It can be either an article in a newspaper, or a fragment from a journal or a book. Find not less than 10 *ing*-forms. Classify them.

Task 15. Below are some sentences from the text. Read them paying attention to the italicized words.

1. Warm surface water is pumped to a vacuum chamber *to produce* steam.
2. A heat exchange uses cold water ... *to condense* spent steam into drinkable water.
3. The floating plant required more electricity than that *to operate.*
4. The challenge ... was how to extract the thermal energy ... *to produce* electricity economically.
5. This low pressure causes the water *to boil* at 72°F.
6. The process causes the steam to *condense* and *mix* with the seawater ...
7. A small portion of the spent turbine steam is directed to a plate-fin condenser, which produces 6 gallons per minute of desalinated water that is used to *irrigate plants.*

8. In September 1994 the station set a world record … generating 270 kw using 151 kw *to operate* its pumps.

9. We proved it is possible *to produce* net power …

10. The OTEC team is studying the use of flexible hose and bottom-mounted pump *to bring* cold water from ocean depth.

11. … the spent cold seawater can be used *to cool* buildings.

Grammar notes 4

The infinitive with "to" frequently expresses purpose, indicating that one action will follow another. It is used to talk about people's purposes, the reasons why they do things. E.g. I went to England *to learn* English. The factory works *to produce* goods.

Task 16. Read the sentences from Task 15 and find 8 cases where the infinitive expresses purpose.

Task 17. Make your own sentences according to the following model:

to heat	to produce
The water is heated to produce heat for the houses	

1. to invent	to move	5. to build	to live
2. to design	to improve	6. to use	to give
3. to mount	to generate	7. to produce	to provide
4. to require	to obtain	8. to spend	to buy

Task 18. Below are two sentences from the text. Read them paying attention to the italicized words.

1. This … cylindrical unit contains structured packings similar to *those* used in industrial cooling towers.

2. OTEC capabilities make the technology ideal for many island nations such as *those* in Caribbean Sea …

Grammar notes 5

The words *this, these, that, those, one, the former, the latter* are often used to avoid repeating a noun. E.g. One of the most fruitful *concepts* is *that* of energy conversion.

Task 19. Consider the sentences from Task 18 and find what words the pronoun *those* substitutes.

Discussion of facts, ideas, and concepts

Task 20. Re-read the text more carefully. This time concentrate on details as well as main ideas.

Task 21. Below is a list of the main ideas the text involves in the wrong order. Re-order the ideas so that they follow the pattern of organization in the text. The first one has been done for you.

		order
(a)	The positive accumulated experience	
(b)	Energy stored in nature	1
(c)	Materials used	
(d)	Condensing	
(e)	Probable application	
(f)	Cooling of the steam	
(g)	Commercializing the process	
(h)	Temperature differential-source for the project	
(i)	OTEC building construction	
(j)	Construction details	

Task 22. In describing some objects or processes people do an objective assessment of attributes. There are sets of rules or principles by which to evaluate quality of something. **Measure** is an actual physical tool to determine the dimensions or attributes of a product. **To measure** means to find the value of a property by comparing its magnitude with a standard. **Measurement** is dimension, quantity, etc., ascertained by measuring with fixed units. These fixed units are various.

Below are fragments from the text. What do these units measure? Consider each example.

250 billion barrels, the sun warms the surface of tropical water to 80°F, at depths of 5000 feet, in 1930, the plant generates 22 kilowatts, the building is 16-sided polygon, I foot thick, twice as thick, 36 inches in diameter, a pipe brings 9000 gallons of water per minute, six high-speed centrifugal vacuum compressors, more than 20 000 rpm, the vacuum-exhaust system is rated at 40 horsepower, the pressure of the seawater is reduced to about 3% of the atmosphere, a 1-mile-long pipe.

Task 23. Sometimes people don't measure anything in units but evaluate the merits by means of qualitative assessment. Such information cannot satisfy a specialist in a narrow field. Imagine yourself being such a specialist. Ask for more accurate information.

Example:

clean source of power

Question: Is it 0 percent pollution?

near freezing temperature

Question: What is the degree?

Cold water; more electricity; porous material; a dense mixture of reinforced, post-tensioned concrete; airtight building; corrosive seawater; many smaller instrument and observation ports; a high-density polyethylene pipe; warm water; high-speed compressor; high-vacuum efficiency; low pressure; low temperature steam; several centrifugal pumps; from the depth of the Pacific Ocean; a small portion of the spent turbine steam; less expensive materials; water is rich in nutrients.

Task 24. Read the following. (*The Hutchinson Pocket Encyclopedia.* Oxford, 1994, p. 198)

Energy — capacity for doing work. Potential energy (PE) is energy deriving from position: thus a stretched spring has elastic PE, and an object raised to a height above the Earth's surface, or the water in an elevated reservoir, has gravitational PE. A lump of coal and a tank of petrol, together with the oxygen needed for their combustion, have chemical energy. Other sorts of energy include electrical and nuclear energy, and light and sound. Moving bodies possess kinetic energy (KE). Energy can be converted from one form to another, but the total quantity stays the same (in accordance with the conservation of energy principle that governs many natural phenomena). For example, as an apple falls, it loses gravitational PE but gains KE.

Energy Alternative — energy from sources that are renewable and ecologically safe, as opposed to sources that are nonrenewable with toxic by-products, such as coal, oil, or gas (fossil fuels), and uranium (for nuclear power). The most important alternative energy source is flowing water, harnessed as hydroelectric power. Other sources include the oceans' tides and waves, wind, the Sun and heat trapped in the Earth's crust-geothermal energy.

Answer the following questions:

1. What kind of energy do tropical oceans absorb each day?

2. What kind of energy do 250 billion barrels of oil with the oxygen needed for their combustion have?

3. How can you explain the fact that alternative sources of energy, renewable and ecologically safe, are not used as frequent as nonrenewable with toxic by-products?

Task 25. Discuss advantages and disadvantages of utilization of the alternative sources of energy. The key word is *efficiency*.

Task 26. Answer the following questions:

1. Why was not the plant designed by Georges Claude off the coast of Cuba duplicated in other areas with the similar climate?

2. What is the vacuum chamber designed for? What does vacuum have to do with boiling of water?

3. Make a drawing of the OTEC building, put all the dimensions on it. Explain how it works.

4. What branches of mechanics and mathematics from your view point found their application in the solution of the problem the designers of OTEC faced with?

Task 27. Historians of science have long debated the relative importance of new concepts and new tools in the development of scientific breakthroughs. The human heritage of inquisitive brains and tool-making hands in every human culture work together to create a civilization. Read and discuss in the class the fragment from the article *Miracles of Rare Device* written by a well-known American mathematician and physicist F. J. Dyson published in *The Sciences* journal where he tries to predict some of the most basic technological changes to come.

What will be the crucial tools of the future? Before making my own modest attempt to see into the twenty-first century, I examined the efforts of Jules Verne and H. G. Wells, two nineteenth-century writers who tried to peek ahead into the twentieth. Verne and Wells both failed to foresee some of the most basic technological changes to come: the dominance of the private automobile over other means of transportation, for instance, and the ubiquity of telephones and personal computers. The biggest mistake they made was thinking that technology would always get bigger and bigger, rather than smaller and smaller.

I do not expect that my efforts at prediction will be any more accurate. I am merely describing one or two possible courses among the millions the future might take. My main concern is to show that the road to a better future exists. Along this road people have a chance to reach a happier and more equitable world.

Changes might come, for instance, from new tools that harness the combined power of the sun, molecular genetics and the Internet. In hamlets and villages around the world, from the jungles of Borneo to the mountains of Peru, people might someday be able to log onto the Internet. If power lines are not accessible, they might get electricity from the sun, either by using photovoltaic collectors or by growing genetically engineered energy crops. If the disadvantaged people of the world can connect to the Internet, they will have access to the information they need to develop their talents and participate in the global economy. Such a change might help address one of the great evils of our time: rural poverty.

People who are far from telephones need access to information by radio. Soon, low-altitude satellites will be within range of every place on earth. But for people without the electricity needed to power radio transmitters and receivers, the satellites overhead will be useless. We need to learn how to make cheap electricity from sunlight all over the earth, if the Internet is to be more than a luxury for developed nations.

Fortunately, solar energy is abundant where it is most needed, in the tropical countries where most of the poorest people live. The two main tools currently used for collecting solar energy — photoelectric panels that produce electricity, and crops that can be harvested to produce fuel — are expensive and inefficient. To make solar energy cheap enough to be practical, new technologies are needed. I believe that genetics holds the key.

Genetic engineering has already proved its usefulness in improving crops. In the future, plants might be developed that would be as efficient as photovoltaic collectors at converting sunlight to fuel. And crops might be engineered that could provide energy without being harvested. A permanent forest of genetically engineered trees might then convert sunlight to liquid fuel and deliver the fuel through the trees' roots to a network of underground pipelines. Such a system would not only provide cheap energy to rural places, but would avoid the havoc of deforestation.

If electricity could thereby become inexpensive and accessible throughout the world, people in remote areas would be able to use the vast global network of interconnected computers to make business deals, keep in touch with their friends and continue their education, with full knowledge of what is going on in the rest of the world. That is my dream: that once the technical obstacles have been overcome, solar energy, genetic engineering and the Internet might work together to create a socially just society, in which every Mexican village could be as wealthy and productive as my hometown of Princeton, New Jersey.

Unit 2

The topic of this unit deals with modeling of biological systems aiming at the creation of more efficient mechanical systems. The involvement of more sophisticated mathematics and computer science here for the solution of the problem in question is obvious.

Reading

Task 1. Read the title, the sub-title of the text and the key words: *engineer, nature, researcher, model, propulsion system, mechanical system, biological system, nervous system, neural system, computer technology, model system, engineering application, very large-scale integrated (VLSI) circuits, motor system, motor control, replicate, sensory feedback, central pattern generator, motor behavior, repetitive action, mechanical model, robotic model.*

Without reading the text what could you guess about its content? What problem will be considered? Make a prediction. Write down as many ideas as you can.

Task 2. Read the text in order to understand the main ideas. Compare your guessed ideas with those considered in the text. Tell where you were right and where you were wrong.

BETTER DESIGNS FROM A BLOOD SUCKER
Understanding the nervous system of a leech may help build better robots

For centuries, engineers have taken inspiration from nature in designing their creations. It's no coincidence, for example, that the shape of an aircraft wing is similar to a bird's.

If researchers were able to more accurately model the propulsion system of, say, a bird or a fish, then perhaps the mechanical systems they produced would be more efficient than those that currently exist. With advances in computer technology — including the development of advanced modeling systems with very large-scale integrated (VLSI) circuits — researchers are now exploring more deeply the way biological systems operate. Greater understanding of the nervous system of a leech, for example, may help engineers develop more efficient mechanical devices, including better motors, pumps, robots, and prosthetic limbs.

"We are now at a point where we can use neural systems as an inspiration for engineering," said Steve DeWeerth, an assistant professor in the School of Electrical and Computer Engineering at Georgia Institute of Technology in Atlanta. DeWeerth has done most of his work in neuromorphic engineering, a field in which researchers study biological systems for potential engineering applications. Researchers have already developed VLSI models of early visual processing in the retina and early auditory processing in the inner ear. But until now they have developed few VLSI circuit models of motor systems, the devices that make biological parts move.

Biological organisms perform sophisticated sensory motor tasks. Fine motor control in the human hand, for example, is extremely complex, and engineers have not yet been able to replicate such a system in a machine. One of the challenges of modeling neural systems is finding the correct level of system complexity. While certain biological systems are too complicated to engineer, replicating a biological system that is relatively unsophisticated doesn't really take advantage of VLSI technology, in which complicated electronic circuits are easily and inexpensively replicated dozens of times.

DeWeerth, a VLSI designer, has teamed up with Ron Calabrese, director of the neuroscience program at Emory University in Atlanta, who is studying neural control of the leech circulatory system and leech locomotion. They are studying how biological motor systems work and how sensory feedback improves performance.

The biological systems they selected — the nervous systems of a leech and a lamprey, an eel-like jawless fish — are particularly suited to VLSI-circuit modeling. The leech's body, for example, is divided into more than 20 segments that operate similarly. The lamprey has 100 such segments along its spine. In both the leech and the lamprey, each segment has a central pattern generator, which the researchers call an oscillator. "An individual oscillator can be modeled with VLSI circuits, and these circuits can be replicated many times to model the entire intersegmental system," DeWeerth said.

Much motor behavior, from a human serving a tennis ball to a fish swimming, is regulated by these central pattern generators, which generate a motor pattern or a repetitive action. When a human walks, for example, the motor pattern for the first step is continuously repeated. Sensory feedback to the central pattern generators helps the human adapt the stride to changing conditions.

A leech's swimming motion similarly uses repetitive movements. By studying this motion, the researchers can observe how sensory input, pattern generation, and reflex action are coordinated to provide efficient propulsion.

DeWeerth and Calabrese plan to build a mechanical model of the leech to test the circuits they develop. The leech model will not swim, however, because the researchers are not studying its hydrodynamics. Instead, the model will oscillate back and forth on a bench making sinusoidal movements.

DeWeerth hopes to eventually merge his work with research into hydrodynamic modeling of mechanical structures. "If we can learn more about both the hydrodynamics and the neural dynamics, we can use this work to build more efficient propulsion systems in water," he said.

An example of this type of hydrodynamic research is underway at the Massachusetts Institute of Technology. Michael Triantafyllou, a research professor, is leading a team developing a robotic tuna to help in studying the fundamental fluid mechanics of how the fish swims and to evaluate control circuits and sensors for ocean-based autonomous-vehicle applications. The MIT researchers plan to launch a 15-foot robotic model in Boston Harbor.

Meanwhile, studying the leech may lead to more than better motors. Its efficient circulatory system may also yield new methods of pumping fluids. And by building physical models of biological neuromotor systems, DeWeerth hopes to develop a thorough knowledge of how the systems work. "If we can understand their organizational principles," he said, "we may be able to build better prosthetic limbs and robots that can move more smoothly and have reflex-like behavior."

Leo O'Connor

Vocabulary

Task 3. Below are some words taken from the text. Try to guess their meaning by thinking about the context in which they are found. In each case choose one of the three answers which you think best expresses the meaning.

inspiration — (line 1)

(a) communication of ideas from a supernatural source;
(b) a bright idea, something conveyed to the mind when under extraordinary influence;
(c) state of animal and plants in which the natural functions are performed.

coincidence — (line 2)

(a) correspondence in nature, circumstances etc., the fact that two or more things share certain characteristics, have identical elements;
(b) a lack of order;
(c) heat and light caused by combustion.

currently — (line 6)

(a) at once;
(b) in a moment, belonging to the present time, generally;
(c) with great force or energy.

explore — (line 9)

(a) to make an attempt to learn more about an unknown; to search through with the view of making discovery, to investigate;
(b) to expose a theory;
(c) to become a member of.

device — (line 12)

(a) an instrument which measures a variable quantity, usually having a scale;
(b) an object cleverly or especially made for a special purpose;
(c) a picture used to make a description.

unsophisticated — (line 31)

(a) simple;
(b) tall;
(c) strange.

advantage (*in* take advantage of) — (line 32)

(a) favorable state, superiority, a factor or set of factors in a competition giving a position of superiority of any kind;
(b) (in tennis) a point gained after deuce;
(c) a state, intermediate between a solid and a gas.

feedback — (line 38)

(a) the upper part of a man's or animal's body;
(b) the action by which the output of a process is coupled to the input;
(c) a reward for services.

eventual(ly) — (line 64)

(a) in a short period of time;
(b) willingly;

(c) that which happens as a consequence, which is bound to follow as the final effect of causes already in operation.

vehicle — (line 74)

(a) the gravitational force between the Earth and a body;
(b) any form of land or air transport;
(c) a substance in which solid substances are suspended.

Task 4. Below is a list of words you came across in the text, which are considered as biological systems in neuromorphic engineering. Neuromorphic engineering is defined in the text (paragraph 3). Scan the text and find some complementary information about those biological systems answering the following questions. The paragraph you'll find the required information is marked.

a human, a bird, a leech, a fish, a lamprey, an eel, a tuna

1. What is an aircraft wing similar to? (1)
2. How do people sometimes call a leech? (the title)
3. What are the researchers attempting to model more accurately to produce more efficient mechanical systems? (2)
4. What was the biological object researchers investigated to develop VLSI models of early visual processing in the retina and early auditory processing in the inner ear? (3)
5. What are motor systems? (3)
6. What is considered to be extremely complex to replicate in a machine? (4)
7. What is Ron Calabrese studying? (5)
8. What is a lamprey? (6)
9. Whose body is divided into 20 segments and whose body has 100 segments? (6)
10. Who has a central pattern generator — an oscillator for each segment along its spine? (6)
11. What are the biological systems, whose motor behavior is regulated by the central pattern generators and what is a motor pattern? (7)

12. Whom does sensory feedback to the central pattern generator help adapt the stride to changing conditions? (7)
13. Whose swimming motion uses repetitive movements? (8)
14. What mechanical model will be built to test the circuits developed by the researchers? (9)
15. What are Michael Triantafyllou and a team he is leading developing to help in studying the fundamental fluid mechanics of how the fish swims? (11)
16. What may lead to more than better motors? (12)

Grammar notes and grammar tasks

Task 5. Below are some sentences taken from the text. Read them and tell where the verb *to have* is a main verb and where it is a helping or an auxiliary one.

1. For centuries, engineers *have* taken inspiration from nature in designing their creations.
2. He may be able to build better prosthetic limbs and robots that can move more smoothly and *have* reflex-like behavior.
3. Researchers *have* already developed VLSI models of early visual processing in the retina and early auditory processing in the inner ear.
4. In both the leech and lamprey each segment *has* a central pattern generator.
5. Fine motor control in the human hand, for example, is extremely complex and engineers *have* not yet been able to replicate such a system in a machine.
6. The lamprey *has* 100 such segments along its spine.
7. DeWeerth, a VLSI designer, *has* teamed up with Ron Calabrese, director of the neuroscience program at Emory University in Atlanta.
8. But until now they *have* developed few VLSI circuit models of motor systems.

9. DeWeerth *has* done most of his work in neuromorphic engineering.

Grammar notes 1

The Present Perfect is used with action or stative verbs, when the speaker is referring to an activity or state which either begins in the past and continues up to the moment of speaking, or occurs at some unspecified time within the pre-past period. If we say that something has happened we are generally thinking about the present as well as the past. When we make a present perfect sentence, we could usually make a present tense sentence about the same situation.

Example:

We have known each other for a long time.

We met 10 years ago.	We are all friends.
(the past)	(the present)

Task 6. Make a past tense sentence and a present tense sentence for each of the six present perfect sentences from Task 5. Show the connection between the past and the present. For more facts consult the text. In your sentences use verbs other than in the basic sentences from the text as in the example above.

Task 7. Below are some sentences taken from the text. Read them and tell where the verb *to be* is a main verb and where it is a helping or an auxiliary one.

1. Researchers *are* now exploring more deeply the way biological systems operate.
2. An individual oscillator can *be* modeled with VLSI circuits.
3. If we can understand their organizational principles we may *be* able to build better prosthetic limbs and robots.
4. The leech model will not swim, however, because the researchers *are* not studying its hydrodynamics.
5. When a human walks, the motor pattern for the first step *is* continuously repeated.
6. Fine motor control in the human hand *is* extremely complex and engineers have not yet *been* able to replicate such a system in a machine.

7. The biological systems they selected *are* particularly suited to VLSI-circuit modeling.
8. The leech's body *is* divided into more than 20 segments.
9. Ron Calabrese *is* studying neural control of the leech circulatory system and leech locomotion.
10. If researchers *were* able to more accurately model the propulsion system then perhaps the mechanical systems they produced would *be* more efficient.
11. Much motor behavior *is* regulated by the central pattern generators.
12. Michael Triantafyllou, a research professor, *is* leading a team developing a robotic tuna to help in studying the fundamental fluid mechanics.
13. We *are* now at a point where we can use neural systems as an inspiration for engineering.
14. An example of this type of hydrodynamic research *is* underway at the MIT.
15. These circuits can *be* replicated many times to model the entire intersegmental system.
16. Sensory input, pattern generation and reflex action *are* coordinated to provide efficient propulsion.
17. Complicated electronic circuits *are* easily and inexpensively replicated dozens of times.
18. Certain biological systems *are* too complicated to engineer.
19. A biological system that *is* relatively unsophisticated doesn't really take advantage of VLSI technology.
20. *It's* no coincidence that the shape of an aircraft wing *is* similar to a bird's.
21. They *are* studying how biological motor systems work and how sensory feedback improves performance.

Grammar notes 2

Be is very often used as a full verb, as in: *He was my best friend. He was so nice.*

Be + present participle is an expression of the Progressive Aspect in which *be* is an auxiliary or helping verb (e.g. They are waiting).

The auxiliary *Be + past participle* produces the Passive Voice, in contrast with the Active Voice. The verb is 'active' in:

(1) The headmaster places George and me in the same class.
but 'passive' in:

(2) George and I were placed in the same class.
For more information consult your grammar book.

Task 8. Write an essay on the topic: "Where robots have been applied, are being applied and will be applied in the nearest future". The essay should not exceed 150–200 words. Try to use *to be* as a full verb and as an auxiliary in not less than 10 sentences.

Task 9. Below are three sentences taken from the text. Study them, and analyse thoroughly the information from the text relating to these sentences. Answer the questions.

1. If researchers were able to more accurately model the propulsion system of, say, a bird or a fish, then perhaps the mechanical systems they produced would be more efficient than those that currently exist.
2. If we can learn more about both the hydrodynamics and neural dynamics we can use this work to build more efficient propulsion systems in water.
3. If we can understand their organizational principles ... we may be able to build better prosthetic limbs and robots that can move more smoothly and have reflex-like behavior.

Questions:

1. Can researchers model accurately enough the propulsion systems of a bird or a fish?
   Are the mechanical systems produced and currently existing efficient enough?
   Is more accurate modeling of the biological objects' propulsion system a fact or a non-fact at the moment?

2. Do DeWeerth and his team know much about both the hydrodynamics and the neural dynamics at the moment?
   Is it a real possibility that they will be able to build more efficient propulsion systems in water?
3. Do DeWeerth and his team understand organizational principles of biological neuromotor systems?
   Is it a real possibility that they will understand it and will have an opportunity to build better prosthetic limbs and robots that can move more smoothly and have reflex-like behavior?

Grammar notes 3

Conditional sentences can be divided into 3 groups.

Type 1: *Present tense in the if-clause, will or imperative in the main clause.* In this type what is said in the main clause is dependent on something that may not happen, though this "something" is assumed by the speaker to be a *real possibility*.

E.g. If you *read* this article { *tell* me. I want to know your opinion. / we *will discuss* it later. }

Can, *may*, *must* are acceptable in the if-clause when *will* is not.

E.g. If you *read* this article we *can discuss* it later.
(See 2 and 3 in Task 9).

Type 2: *Past in the if-clause, would in the main clause.* Here what is said in the main clause is an imaginary consequence of a *present non-fact*. The if-clause states the non-fact and its verb is accordingly in the past tense.

E.g. If you *read* [red] this article we { *would discuss it.* / *could discuss it.* }

If I *were* you I *would read* this article. (See 1 in Task 9).

Type 3: *Past Perfect in the if-clause, would + perfect in the main clause.* What is said in the main clause is now seen as an *imaginary consequence* of *a past non-fact* — something that did not happen.

E.g. If you had *read* [red] this article we *would have discussed* it,
or we *could have discussed* it.

Task 10. Make if-clauses considering each action or state in the first column as: a) a real possibility; b) a present non-fact; c) a past non-fact; add a main clause using the verb in the second column:

I		II
to have any vehicle	—	to come in time
to use a computer	—	to solve a problem
to swim faster	—	to win a prize
to understand better	—	to design a device
to perform a task	—	to be the first
to be a researcher	—	to develop ...

Discussion of facts, ideas and concepts

Task 11. Read the first two paragraphs, thoroughly analyze the facts stated and answer the questions.

1. What is the system researchers are planning to more accurately model?
2. What is supposed to be improved being a result of the research described in the text?
3. What advanced device will help to explore more deeply the way biological systems operate?
4. What is meant by more efficient mechanical devices in the text?

Task 12. One of the key words in the text is *MODEL*. Read the definition from *Longman Dictionary of Scientific Usage*.

Model. A model is a physical device which represents an object. By examining the model we can find out facts about the object, e.g. a model of a bridge; a model of the solar system. Such models are called *representational models*, and they can be described as *true*, *adequate*, *distorted* or *analogue* models.

A *true model* is one made accurately to a known scale (also known as a *scale model*), e.g. a model of a bridge in which the length, breadth, and thickness of each part in the model is exactly 1/100 of the corresponding measurements in the bridge.

An *adequate model* is one in which only some of the measurements or characteristics are made to a scale, but sufficient detail is given for the purpose of the model.

A *distorted model* is one which uses different scales for different characteristics or measurements, e.g. a model of the solar system in which the distances between the planets are on a different scale because otherwise they would be too small to see.

An *analogue model* represents an analogy with the object. For example there is an analogy between the diffusion of molecules in a gas and the movement of a swarm of bees. The movement of the swarm of bees is the model; the diffusion of gas molecules is the object. An analogue model need not be built, but only described.

A *theoretical model* describes an object or a system by using observables, the behaviour of which explains various properties shown by the object or system. The model is not built, only discussed. Usually the theoretical model uses an analogy of the object or system, e.g. **a)** the Kinetic Theory of Gases uses a billiard ball model to describe the structure of a gas. A billiard ball is an observable, and the behaviour of the billiard balls explains the properties of the gas. In a theoretical model, the characteristics of the observables must be stated, i.e. that billiard balls have the characteristic of being perfectly elastic; **b)** the passage of an electric current through metals is explained by the free-electron model of metals. Note the difference between a theoretical model and an analogue representational model. In a representational model, steel balls moving on a tray represent gas molecules, and no characteristics are stated. In the theoretical model the behaviour of the billiard balls describes the behaviour of the gas molecules. The description of the behaviour is more accurate than the representation of the behaviour of gas molecules.

Longman Dictionary does not give a definition of a mathematical model. Try to formulate what is a mathematical model.

Task 13. DeWeerth and Calabrese plan to build a mechanical model of the leech to test the circuits they develop. The leech model will not swim, however, because the researchers are not studying its hydrodynamics. Classify the type of the model the researchers plan to build. How does the model move? What is the final goal of their research? Do they have any kind of competition? What are their competitors working on and what is underway at the MIT?

Task 14. It is a well-known fact that research in any sphere demands great investments. The money can be taken either from a state budget, or from private investors. The money the private investor owns comes from business. Imagine yourself being a businessman and tell what kind of product you would like to produce if you had enough money to invest into the researches described in the text. Give your arguments.

List of products:

(1) better motors;

(2) pumps based on better methods of pumping fluids;

(3) robots } that can move more smoothly

(4) prosthetic limbs } and have reflex-like behavior;

(5) more efficient propulsion systems in water;

(6) ocean-based autonomous vehicles.

Task 15. Below are the words taken from the text.

research (n)	—	engineering (n)
to research (v)	—	to engineer (v)
researcher (n)	—	engineer (n)

They are rather frequently used in the text, because the article tells us about the joined efforts of researchers and engineers to produce better devices. Both research and engineering are spheres of human intellectual activity. *Research* is a diligent search or seeking of facts and principles, scientific investigation or study to discover facts, while *Engineering* is the application of science to the design, construction, and maintenance of works, machinery, roads, railways, bridges, harbour installations, engines, ships, aircraft and airports, spacecraft and space stations and the generation, transmission, and use of electrical power. The main divisions of engineering are aerospace, chemical, civil, electrical, electronic, gas, marine, materials, mechanical, mining, production, radio and structural. Neuromorphic engineering is mentioned in the text. *Engineer* literally means to lay out and manage the construction of some project.

Find the sentences in the text which will give you more information about the particular activity of researchers and engineers in developing and designing better devices. (7 cases with **engineer** and its derivatives, 10 cases with **research** and its derivatives.)

Tell what attracts you more:
(1) searching of facts and principles, or
(2) realization of new findings of scientists
in new devices, technologies, etc.

Give arguments to support your ideas.

Task 16. The object of the research described in the text is to build a physical model of biological neuromotor systems, to develop thorough knowledge of how the systems work and what are their organization principles. Read the text again and answer the following questions.

1. What biological objects are discussed in the text?
2. What interests the researchers in biological systems?
3. What interests the engineers in biological systems?
4. What have you known about the biological objects' motor behaviour?
5. Why does the replication of motor control in the human hand in a machine prove to be a very complicated problem?
6. Why are the leech circulatory system and its locomotion expected to be replicated?
   Locomotion — the action of an individual organism in moving itself from place to place; this ability is usually restricted to animals. Locomotion of an organism is brought about by movements of parts of the body. Methods of locomotion include running, walking, flying and swimming.
7. Sensory input, pattern generation, and reflex action are coordinated in a leech to provide *efficient propulsion*. *Propulsion* — the action of propelling an object, e.g. a jet engine is used for the propulsion of an airplane.

Leech's swimming is a propulsion motion.

Fill in the blanks. Insert any information you think appropriate.

1) Fish's swimming is ... . How does a fish move?
   Describe what a fish does to move.
2) Bird's flying is ... . How does a bird fly?
   Describe what a bird does to fly.
3) Snake's crawling is ... . How does a snake crawl?
   Describe what snake does to crawl.

(Describe the mechanical part of each motion in the Newtonian mechanics.)

8. What probable applications of the results obtained can you see?

Task 17. Read the text and discuss it in the class.

WHEN ROBOTS DO THE REALLY DANGEROUS JOBS

Robots that can strip radioactive waste from ventilation ducts or seal spent fuel and debris inside secure metal containers reduce the risks for human operators. They are opening up the field for consultants, engineers and companies to tackle the 100-year task of making Britain's obsolete nuclear power stations safe for future generations.

Once at the forefront of the postwar race to develop a source of low-cost energy and plutonium for atom bombs, Britain is now a world leader in clean-up technology.

Nuclear decommissioning is a painfully slow process that has to be carried out step by step and costs in Britain will run into tens of billions over the next century.

Key to cutting long-term costs are robots, which carry out a range of tasks, such as controlled-circuit TV inspections, pumping and removal of radioactive sludge, and heavy-duty tasks.

On a project at nearby Sellafield, a floating robot is being used to drain and dismantle a tank of highly active liquid waste. David Young, of BNFL, says: "At Sellafield we have had to invest £20 million in a new ventilation system and robots just to get the work started. The sums involved are enormous but robots used in the early stages can pave the way for conventional civil engineering and demolition operations."

Stephen Hoare

Unit 3

In this unit you will read a text taken from *Newsweek.* It will give you an idea of how the facts gathered by study, investigation or observation as well as ideas acquired by inference from such facts and tricky insight in one branch of learning can be employed for understanding some processes occurring in living organisms, which is the subject of investigation in the other branch of learning. These two branches of learning are mathematics and biology.

Pre-reading tasks

Task 1. Before you read the main text try to answer a question. **Is mathematics an art or a science?** To help you answer this question below is the article from *Webster's Dictionary of Synonyms* which discriminates these two words.

Art, science are comparable when they designate a branch of learning. **Art** (especially as it is found today in the phrases: the liberal art, bachelor of arts, master of arts) historically refers to one of the fundumental branches of learning regarded as necessary to every educated person and serving as an instrument for his advancement in knowledge not only generally but specifically in his professional studies. In the Middle Ages, the liberal arts were grammar, logic, rhetoric, arithmetic, geometry, music, and astronomy; with these as a foundation, a student was ready to proceed with his studies in philosophy, theology, law or the like. In modern times, the liberal arts, as interpreted by various colleges giving arts degrees, are the disciplinary or instrumental branches of learning, as distinguished from those that are technical or professional in their character; or, often, the cultural, as distinguished from the vocational, studies. **Science** was also used in the late Middle Ages and the Renaissance as a branch of learning. It was not identical with **art**, however, because it was not restricted to studies giving the rudiments or providing the apparatus for further study, but was applied to any branch of learning that was a recognized subject of study.

Since the nineteenth century, especially in reference to departments of knowledge or courses given in schools, colleges, and universities, these words show a wider divergence in implications and applications and a tendency (especially in the plural forms) to be used as generic terms. On the one hand, art is applied to those courses which have for their end teaching students to make or do something that requires skill and a knowledge of technique, and also, usually, special gifts such as inventiveness, taste, or ingenuity; as the manual arts; the fine art of painting; instructions in the arts of design. On the other hand, **science** is applied only to such courses (or generally, to all such courses or studies) as deal with the gathering and classification of facts, the drawing of correct inferences from them, and the establishment of verifiable general laws; as the **science** of physics, of botany, of economics; to major in **science**; teachers of **science**. Still other distinctions are drawn between the two, when **art** or **science** refers not so much to a branch of learning as to a pursuit for which one is prepared by the study of an art or science; thus, questions arise as to whether architecture is an **art** or a **science**, that is, (1) whether its essential demands of the architect are inventiveness, taste, and technical skill, or a knowledge of the principles of physics, of engineering, and of other related sciences; (2) whether the end to be served is to give aesthetic pleasure or to produce something useful. 'Hence rhetoric was for Rome both an art and a science ... It had obvious utilitarian value, and its materials were not only exact logical concepts, but the sonorous words and the noble rhythms which were the glory of their tongue' (Buchan).

Task 2. The following pattern of organization is often found in most of sciences. This is a very common way of structuring the subject matter. Study the two strings below, they are followed by formal definitions taken from various dictionaries.

science *mathematics*	science *biology*
branch of science *geometry*	branch of science *cytology*
sub-branch of science *topology*	sub-branch of science *nucleic function*
particular object *knot*	particular object *DNA*

mathematics — science of spatial and numerical relationships. The main divisions of *pure mathematics* include geometry, arithmetic, algebra, calculus and trigonometry.
geometry — branch of mathematics concerned with the properties of space, usually in terms of plane (two-dimensional) and solid (three-dimensional) figures. The subject is usually divided into *pure geometry*, which embraces roughly the plane

biology — science of life. Strictly speaking, biology includes all the life sciences — for example, anatomy and physiology, cytology, zoology and botany, ecology, genetics, biochemistry and biophysics, animal behaviour, embryology and plant breeding. At present an important focus of biological research is the international Human Genome Project, which attempts to map the entire genetic code

and solid geometry dealt with in Euclid's *Elements*, and *analytical* or *coordinate geometry* in which problems are solved using algebraic methods. A third, quite distinct type includes the non-Euclidian geometries.
topology — branch of geometry that deals with those properties of a figure that remain unchanged even when the figure is transformed (bent, stretched).
knot theory — a branch of algebraic topology concerned with the classification of *knots* which, for the purpose of the theory, are defined to be subspaces of the Euclidian space $\mathbb{R}^3$ that are homeomorphic to the circle S^1; two such knots are defined to be equivalent if there is a homeomorphism of $\mathbb{R}^3$ throwing one knot onto the other.
The chief algebraic invariant used in knot theory is the *knot group*, defined to be the fundamental group of the complement of the knot in $\mathbb{R}^3$.

contained in 23 pairs of human chromosomes.
citology — the study of the structure, behaviour and function of cells of animals, plants and bacteria.
nucleic function — a study of
nucleus — a spherical or ovoid body, present in almost all living cells of animals and plants. Nucleus contains the structures controlling the reproduction and functioning of the cell; these are DNA contained in chromosomes.
DNA — (deoxyribonucleic acid) a long chain compound formed from many nucleotides bonded together as units in the chain, complex two-stranded molecule. By convention, one strand is called positive and the other is called negative. The strands can be separated by heat. The molecule contains in chemically coded form all the information needed to build, control, and maintain a living organism. DNA is a ladderlike double-stranded nucleic acid that forms the basis of genetic inheritance in organisms.

Task 3. Below are some words, terms in a sense, the precise meaning of which is absolutely necessary to understand the text. Consult a dictionary, be sure you know what they mean.
Curve, closed curve, plane curve, circle, knot, closed loop, chain, strand, trefoil knot, globe-shaped, string, texture, braid, disc, plate-shaped disc, link, helix, knotlike structures and surfaces, torus, ribbon.

Reading

Task 4. Skim the text quickly.

A KNOTTY PROBLEM UNTANGLED
Mathematics: Possible payoff for DNA research

Warning: don't look down at your shoes until you've read this article. You may never be able to tie them again.

Two simple closed curves in E^3 may be said to be equivalent if there is an orientation-preserving homeomorphism of E^3 onto itself which throws one curve onto the other. Then a simple closed curve J is unknotted if it is equivalent to the plane circle in E^3 with the equation $x_1^2 + x_2^2 = 1$, $x_3 = 0$ ...

To those fluent in language of mathematics, that's a simple explanation of how you tie your shoelaces. The knot that holds your Nikes on your feet and your grandmother's apron at her waist has been the subject of mathematical speculation for centuries — and has long been considered one of the, well, knottiest problems in topology, the branch of math that studies the unchanging properties of geometric figures. But now a classic problem in knot theory may have been solved: mathematician William Menasco of the State University of New York at Buffalo has figured out how many steps it takes to untangle even the trickiest knots. His elegant solution won't make it any easier to straighten out your shoelaces when you're already late for the tennis court or the football field, but it does promise insights into biology (where DNA looks a lot like a knot) and some branches of mathematics.

Unlike knots in shoelaces, math knots don't really have two ends. Instead they are closed loops, more like a gold chain. To make a "knot," unclasp the chain, twist and loop the strand several times, then fasten the clasp. The resulting closed curve is what mathematicians call a knot. (Others call it a mess.) The simplest knots, requiring only a single twist, are called trefoil knots, and look like a globe-shaped pretzel. When British scientist Lord Kelvin proposed in the 1800s that chemical elements were made of knotted-up strands of the supposed universal element ether, trefoil and its more complex cousins took on a new importance. To explain the known elements, Kelvin asked two colleagues to list all the hundreds of ways a string could be knotted. Although elements turned out to be made of atoms rather than knots, by then mathematicians were hooked on knot theory.

One of the earliest challenges was to *undo* the knot — which turned out to be a lot harder than straightening out a gold chain left in a drawer too long. Mathematicians didn't even aspire to figuring out how to untangle a knot: they willingly settled for discovering merely how many steps the operation would require. So since Kelvin's time, theorists have struggled to come up with an algorithm — that is, a procedure — for determining the least number of steps required to unknot a knot — the so-called unknotting number. The hope was that it would be related to what mathematicians did know about a knot — such as how many strands it had, how many times it crossed over itself, whether it lay left- or right-handed — and that these vital knot statistics could be combined in a simple equation that would spit out the unknotting number. Starting with the trefoil, American mathematician John Milnor in 1954 did work out a simple mathematical relation between the unknotting number and two other numbers. It turned out to be too simplistic.

Tricky insight: The deeper secrets of knotting and unknotting, topologists started to suspect, lay in knot qualities that resembled shape, and texture. By the early 1980s they were trying to crack unknotting by seeing how the mysterious twists were oriented in space. Menasco built on this work to figure out, in essence, that the unknotting number had to be less than or equal to a mathematical mixture of crossing numbers, the number of strands in the knot and the braid index (a measure of how a knot twists). The proof required a tricky bit of insight: Menasco manipulated the knot loops as if they were plate-shaped discs. But the result was a value for the unknotting number good for all knots and links, from the simplest overhand to the most convoluted Eagle Scout special. Menasco also credits the independent work of mathematicians Peter Kronheimer of Oxford University and Tom Mrowka at the California Institute of Technology for some of his success. "It's a remarkable proof and a remarkable conclusion," he says. "Everything balances out so that we can find the unknotting number."

The proof should be of great use to biomathematicians who are exploring how DNA knots itself up inside a cell. Before cells divide, the DNA in their nucleus has to copy itself. To replicate, the double helix must first uncoil, opening itself up to the biological equivalent of a photocopier. The Menasco solution may inspire simpler, more elegant models of how genes replicate during embryo development and growth, and how replication goes awry in, for instance, cancer.

The result should also help other topologists who are struggling to explain problems and find proofs involving knotlike structures and surfaces, such as a torus (doughnut shape) and a ribbon. Menasco modestly says that his proof is just one step toward the full understanding of knots. But knowing there's a whole world of Ph. D. mathematicians struggling to make the world safe for knots, you can probably look down at your shoes without fear.

Or you can buy a pair of loafers.

JOSHUA COOPER RAMO

Vocabulary

Task 5. Below are some words taken from the text. Try to guess their meaning by thinking about the context in which they are found. In each case choose one of the three answers which you think best expresses the meaning.

payoff — (sub-title)

(a) something that proves profitable;
(b) salary;
(c) sweet, juicy fruit.

speculation — (line 11)

(a) practice of buying shares, etc. in the hope of selling at high profit;
(b) act of theorizing, seeking a better understanding of a problem on the basis of little or no evidence;

(c) due proportion between several parts of object.

insight — (line 20)

(a) the state of being in motion;
(b) systematic exercise for instruction, training;
(c) a highly developed mental ability to see or understand what is not obvious, the power to recognize the hidden strings of behaviour or the nature or cause of a situation or condition by a more profound use of intellect and wisdom.

aspire — (line 38)

(a) to exist or go together without conflict;
(b) to have as a controlling desire something beyond one's present power of attainment, to desire with eagerness; to aim at high things;
(c) to give explicit direction or clear guidance to those who accept one's authority.

resemble — (line 54)

(a) to be roughly similar but not exactly alike;
(b) to bring together, to fasten, to unite;
(c) to express in definite form.

convoluted — (line 64)

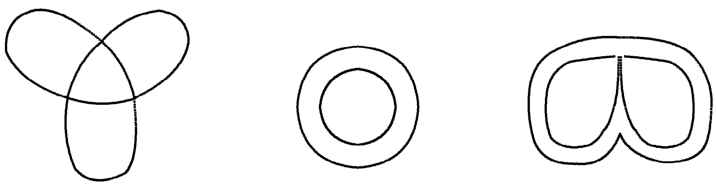
(a) without beginning or end in relation to time;
(b) opposite in order or relation;
(c) rolled together; involved, spiral.

credit — (line 65)

(a) to sell or lend to, in confidence of future payment;
(b) to put trust in;
(c) to lay something to the account to a person, to ascribe the thing to some person as its author.

Task 6. There is a play on words in the headline. Find it and explain it.

Task 7. Look at the figures and tell which one is *pretzel*, *trefoil* or *doughnut*.



Grammar notes and grammar tasks

Grammar notes 1

Prepositions, prepositional phrases, phrasal verbs

The correct choice of a proper preposition is very often a great problem for those learning English. We can classify the problems with several distinct cases for you to identify them and to understand what should be taken into consideration in each case when you are having a problem with prepositions and adverb particles.

1. Most of the prepositions have several functions.
   (**at** has about eighteen main uses)

2. Different prepositions have very similar uses.
   (**in** the morning, **on** Monday morning, **at** night)

3. Many nouns, verbs and adjectives are used with particular prepositions.
   (congratulation **on**, arrive **at**, angry **with** smb., **on** a bus)

4. The two-part verbs in combinations like **give up**, **give in** (both meaning "surrender") or **come about** (=happen) called **phrasal verbs** have quite a different meaning which is not clear from the two separate parts.

* * *

1. A primary function of an English preposition is to express a relationship in *space* between one thing and another. It can refer *to position or to movement in one direction or another*. It can express position or movement in relation to something that the speaker imagines as *a point* or place (with no dimensions, or dimensions that do not matter); or as *a line* (with one dimension); or as *a surface* on which something can rest (with two dimensions); or *a space* in which something can be enclosed (with three dimensions). Commonly used English prepositions can therefore fit into the following scheme:

	point	line or surface	space or area
movement $\longrightarrow \times$	to $\times$	on *or* onto	in *or* into
resulting position	at $\times$	on	in
movement $\longleftarrow \times$	(away) from $\times$	off	out of
resulting position	away from $\times$	off	out of

Similarly, we can have movement (or position) *along* a line, *across* a surface, or *through* a space; or position after one has gone *across* a line or surface, or *through* a space.

2. Prepositions can also express relationships in time:

   E.g. We waited *until* eight o'clock. You must be back *in (within)* fifteen minutes. I do most of my work *in* the morning.

   and can express other ideas, such as *destination or purpose* (*for*, *for* my professor), *agency* (*by*, It is written *by* my friend) or *instrument* (*with*, He cut the finger *with* his knife).

3. Particular prepositions are used after particular words and expressions:

   E.g. I entirely *agree with* you. I must *apologize for* disturbing you. Are you any *good at* tennis?

   Particular prepositions are used before particular words and expressions:

   E.g. *in time* = with enough time to spare; not late
   on time = at exactly the right time
   in my opinion

   Some expressions are used without prepositions:

   E.g. See you next Monday. You can come any day you like. She is the same age as me.

4. Many English verbs consist of two parts: a "base" verb (like *bring, take, come*) and another "small" word (like *up, down, off, away*). In some cases the meaning of a two-part verb is simply a combination of the meanings of the two words. In such a combination we often have a choice of preposition according to the exact relationship in space (come *into* the room, sit *on* a chair). Here *into* and *on* have their basic physical meaning.

   In some cases, the first word keeps its meaning, but the second (adverb particle) has a special "intensifying" sense and has some secondary meaning. For example, *on* can mean "forward", as in *go on*, *keep on*, *play on*; *up* can indicate completion of an act, as in *eat up*, *drink up*, *wake up*, or stop, as in *give up*; *in*, collapse, as in *give in* etc.

   In other cases the new two-part verb has quite a different meaning from the two separate parts: *give up*, *give in* (both meaning "surrender") or *come about* (=happen). Such combinations are idioms, and are called phrasal verbs.

   A direction may be indicated twice or even three times in the same phrase.

E.g. Go *up to* my office.
Go *on* (=forward) *up to* my office.

Idioms like *put up with* (=tolerate) and *run out of* (=exhaust) may have three components.

Phrasal verbs summarized

Type	Structure	Example
1	verb + preposition	We came across my friend.
2	verb + adverb particle	Don't give in.
3	verb + object + adverb particle *or* verb + adverb particle + object	Bring a child up. Bring up a child. Bring him up well.
4	verb + adverb particle + preposition	We've run out of bread.

Phrasal verbs are common in *informal* English. We can often replace them with one word, which is more *formal*.

E.g. He decided *to carry on*. (=continue)
Don't *leave out* anything important. (=omit)

Note: There are a number of nouns, *e.g.* **outcome**, **output**, **input**, formed from the constructions **come out**, **put in**, **put out**.

Task 8. Below is the list of *prepositional phrases* and *phrasal verbs* you have found in the text. Consider them. Be sure you understand their meaning.

1) Look *down at* your shoes; 2) homeomorphism *of* E^3 *onto* itself; 3) throw one curve *onto* the other; 4) is equivalent *to* the plane circle *in* E^3 *with* the equation ... ; 5) *to* those fluent *in* language *of* math; 6) explanation *of* how ... ; 7) ... holds your Nikes *on* your feet; 8) hold ... apron *at* her waist; 9) the subject *of* mathematical speculations; 10) *for* centuries; 11) one *of* problems; 12) problems *in* topology; 13) the brahch *of* mathematics; 14) a problem *in* knot theory; 15) M. of the ... University *at* Buffalo; 16) *figured out* how many ... ; 17) *to strengthen out* your shoelaces; 18) you're ... late *for* the tennis court; 19) insights *into* biology; 20) DNA looks ... *like* a knot; 21) unlike knots *in* shoelaces; 22) they are ... *like* a gold chain; 23) they *look like* a globe-shaped pretzel; 24) proposed *in* the 1800s; 25) elements made *of* ... strands *of* ... the element; 26) trefoil *took on* a new importance; 27) elements *turned out* to be made *of* atoms; 28) mathematicians were *hooked on* knot theory; 29) a chain left *in* a drawer; 30) they *settled for* discovery; 31) theorists have struggled to *come up with* an algorithm; 32) a procedure

for determining; 33) it would be *related to* what ... ; 34) how many times a knot *crossed over* itself; 35) knot statistics could be *combined in* a simple equation; 36) ... equation would *spit out* the unknotting number; 37) starting *with* the trefoil; 38) *in* 1954; 39) M. did *work out* a simple relation; 40) relation *between* ... the number and two numbers; 41) ... secrets *lay in* knot quality; 42) *by* the early 1980s; 43) to crack unknotting *by* seeing how ... ; 44) ... were oriented *in* space; 45) M. *built on* this work; 46) *in* essence; 47) a value *for* the unknotting number; 48) good *for* all knots; 49) *from* the simplest overhand to the ... ; 50) P. K. *of* Oxford University; 51) T. M. *at* the California Institute *of* Technology; 52) M. credits P. K. and T. M. *for* some of his success; 53) everything *balances out* so that ... ; 54) the proof should *be of great use to* the biomathematicians; 55) how DNA *knots itself up inside* a cell; 56) *before* cells divide; 57) DNA *in* their nucleus has to copy itself; 58) *opening itself up to* the biological equivalent of photocopier; 59) *during* embryo development and growth; 60) replication goes awry *in* ... cancer; 61) *for* instance; 62) proof is just one step *toward* the ... understanding; 63) to make the world *safe for* knots; 64) *without* fear.

Task 9. Match a phrasal verb in *A* with its equivalent in *B*. If necessary consult either the text or a dictionary.

A	B
to balance out	to have an idea about *sth*
to build on	to produce *sth* from (a material)
to come up with	to be in a state in which no one part, element, factor, or influence overweights another or is out of due proportion to the others
to cross over	to say (*sth*) with effort
to figure out	to move across (a road, a string, etc.)
to hold on	to base (*sth*) on (*sth else*)
to be hooked on	to cause (*sth*) to begin by having or doing *sth*
to look down at	to direct *sth* onto *sth*

to make of	to understand *sth* with difficulty
to spit out	to watch *sth* below
to start with	to keep on not to let go from the foot
to straighten out	to result, develop or end
to take on	to be keen on doing *sth*
to throw out	to invent, develop or produce by thinking
to turn out	to seem or begin to have (a quality, form or appearance)
to work out	to (cause to) become more straight
to settle for	to accept (*sth* or doing *sth* less than one had hoped)

Task 10. Review Sequence of Tenses in your grammar book, p. 32. Translate the following sentences.

1. They willingly settled for discovering merely how many steps the orientation *would* require.
2. The hope was that it *would* be related to what mathematicians did know about a knot.
3. The hope was ... that these vital knot statistics *would* be combined in a simple equation.
4. The hope was that a simple equation *would* spit out the unknotting number.

Grammar notes 2

In the texts of academic character which are concerned with science or other branches of learning dealing with inferences drawn from observed facts or from the results of experiments, or with the laws or theories that explain them, the writers very often state the facts and ideas not as being absolute truths but as being uncertain yet such as may be, or may become true, real, or actual in case they have a certain degree of evidence in their support. There are various means in English to help a speaker or a writer to express **supposition, doubt, uncertainty**.

I. Adjectives and adverbs

Adjectives: probable, likely, hopeful, presumable, presumptive, apparent, verisimilar, in a fair way; credible, believable, trustworthy; reasonable, well-founded, specious, plausible, colorable, ostensible.

Adverbs: probably, presumably, etc. (see *adjectives*); seemingly, in all probability, most likely, in all appearance.

II. Modal verbs: must, should, ought, may (might), can (could)

E.g. He **must be** a well-known scientist now, I read his early works they were extremely talented.
The proof **should be** of great use to biomathematicians.
You **may** never **be able** to tie them again.
Two closed curves in E^3 **may be said** to be equivalent.
But now a classic problem in knot theory **may have been solved**. He **might have solved** the problem but he did not tell anybody about it.
But knowing there's a whole world of Ph. D. mathematicians struggling to make the world safe for knots, you **can probably look** down at your shoes without fear.
Or you **can buy** a pair loafers.
The hope was ... that these vital knot statistics **could be combined** in a simple equation.

III. Complex subject
In case the speaker or the writer doesn't want to give a great prominance to the absolute evidence of the facts or ideas he states, also when he prefers to make a statement less personal he may use the **Complex Subject** construction (see your grammar book, p. 21).

E.g. 1. **This physicist is known to have delivered** an interesting lecture on this subject.
2. **This scientist seems to have made** an important discovery.
3. **This scientist is likely to make** an important discovery.

Task 11. Recast the following sentences. Use **must** instead of modal words.

Model:

1. She is probably in her office now.
   She must be in her office now.
2. Surely they have left already.
   They must have left already.

1. Her shoelaces are *evidently* worn they don't hold her Nikes on her feet.
2. *Surely* my grahdmother's new apron is the one I presented her on Christmas.

3. *No doubt* you are run down, you look pale and tired.
4. You *probably* want a good deal of exercise to put you in proper shape.
5. She is *obviously* well up in differential analysis.
6. Topologists were *undoubtedly* struggling to explain problems and find proofs.

Task 12. Make sentences around key words with **should, ought, may, might, can, could** as at the right.

Model:

be able to	You may never be able to tie your shoes again.
hold at	These new strings should hold your apron at your waist tightly.
consider	Could you have considered the opportunity to be the best at the competition?

Key words: solve, figure out, promise, fasten, require, propose, explain, undo, aspire, determine, cross, combine, build on, manipulate, credit, balance out, replicate, inspire.

Task 13. Fill in the blanks with the corresponding verbs (*consider, assume, believe, turn out, know, prove, show, seem*).

1. The diameter of the sun ... to equal about 1,391,000 km, thus, it is thousands of times larger than the earth.
2. No material ... to be perfectly elastic even at very low stress.
3. The question whether the atom can or cannot be split up ... to have interested scientists from ancient times.
4. The earth ... to have formed from the same material that gave rise to the sun and the other planets.
5. We see from Figure 2 that magnitude is an even function of frequency and phase is an odd function of frequency, which always ... to be the case.

6. Comparatively few of the elements ... to occur as uncombined substances in nature, most of them being found in the form of chemical compounds.
7. Cosmic rays ... to be a form of radiation similar in nature to those of radio and light and differing from them only in wavelength and penetrating property.
8. There ... to be almost universal agreement that the traditional methods of storing and searching for information are not efficient enough at the present time and will become less so in the future.
9. The number of stars which is seen within the range of the naked eye ... to be about 6000.
10. For two thousand years the basic laws of geometry offered by Greek scientist Euclid ... to be indisputable.

Task 14. Change the sentences using the *Complex Subject* construction.

1. It is known that inertia is one of the fundamental characteristics of matter.
2. It is supposed that Hippocrates has discovered many of the important properties of the circle.
3. It is likely that in many cases the truth of this law is evident.
4. It turns out that the rules of arithmetic for complex numbers are the same as those for real numbers.
5. It was not observed that this substance possessed radioactive properties.
6. It may be expected that the atom radiates energy in this case.
7. It is said that particle A, moving in a circle with constant speed, is in uniform motion.

8. It was shown that the ether concept was superfluous.

9. For nearly a century it was assumed that atoms were the indivisible particles of the elementary substance.

Discussion of facts, ideas, and concepts

Task 15. The word *knot* is a key word in the text. The author uses this word and its derivatives 40 times. He uses it as we do in our everyday life with the meaning of a complication of threads, cords, or ropes, formed by tying or entangling, or as ribbons folded in different ways. The author also uses the word as a term in mathematics, in topology particularly. Knotlike structures are also mentioned in the text. As well the author writes about DNA which knots itself up inside a cell. So as one can see *knot* is a polysemantic word.

Re-read the text more carefully. This time concentrate on details as well as main ideas. Stop each time you come across the word *knot* or its derivatives.

1. Identify, what part of speech it is (noun, verb, adjective etc).

2. State the meaning of each word in the particular context.

3. Try to find an adequate equivalent in Russian for each case.

Task 16. Answer *T* if you think the statement is true and *F* if you think the statement is false. Correct any false statements so that they express accurately what is in the text.

a) Don't look down at your shoes until you've read this article.

b) It is impossible to explain mathematically how you tie your shoelaces.

c) The subject of mathematical speculations for centuries has been how to make money.

d) Topology is the industrial port, commercial centre and the capital of Maharashtra, W. India.

e) A classic problem in knot theory that is how many steps it takes to untangle even the trickiest knots seems to have been solved.

f) DNA looks a lot like a device for converting stored energy into useful work or movement.

g) Math knots do have much more than two ends.

h) To make a 'knot', enter a building, steal a gold chain, do damage the property, harm any person.

i) After you twist and loop a strand of a gold chain several times then fasten the clasp, it will be a mess, that is the chain will be in disordered, disorganized condition.

j) Lord Kelvin is the 35th president of the USA (1961–1963), a Democrat; the first Roman Catholic and the youngest person to be elected president.

k) Kelvin William Thomson, the 1st Baron Kelvin (1824–1907), is the Irish physicist who introduced the *Kelvin scale*, the absolute scale of temperature. His work on the conservation of energy (1851) led to the second law of thermodynamics.

l) Chemical elements are made of knotted-up strands of the supposed universal element ether.

m) One of the earliest challenges for mathematicians was to undo the knot, which turned out to be a hard job.

n) Mathematicians willingly settled for discovering how many steps the operation of untangling a knot would require.

o) An algorithm is a procedure for determining the least number of steps required to solve a problem.

p) An unknotting number is a camera that uses a mirror and prisms to reflect light passing through the lens into the viewfinder, showing the photographer the exact scene that is being shot.

q) Vital knot statistics combined in a simple equation spit out the unknotting number.

r) The American mathematician in 1900 did work out a simple mathematical relation between the unknotting number and two other numbers.

Task 17. Re-read the lines from "So since Kelvin's time," to "we can find the unknotting number" (ll. 40–69).

Explain the difference in the approach of how to find the so-called unknotting number worked out by all the mathematicians mentioned in this fragment from the text.

Task 18. Explain how the solution of the knot-problem in mathematics can affect the understanding of how replication goes awry in, for instance, cancer.

Task 19. Can you think of some other steps toward the full understanding of knots. Discuss your ideas in the class.

Task 20. *Explain:*

1. What are you doing step by step to tie your shoelace?
2. What happens to a gold chain when you leave it careless in a drawer with other things too long unclasped?
3. What happens to DNA when it replicates itself?
4. What does a person do when he or she is making a braid out of his or her hair?

Task 21. The text you have read and discussed in this unit tells about the classic problem in knot theory which seems to have been solved by mathematician William Menasco. He built on the works of other mathematicians who had suspected that the deeper secrets of knotting and unknotting lay in knot qualities that resembled *shape* and *texture*. Menasco figured out in essence that the unknotting number had to be less than or equal to a mathematical mixture of crossing numbers, the number of strands in the knot and the braid index (a measure how a knot twists). The proof required a tricky bit of insight. The proof itself is not given in the paper. The only commentary on it is: Menasco manipulated the knot loops *as if they were plate-shaped discs. The result was a value for the unknotting number good for all knots and links, from the simplest overhand to the most convoluted ones.* (Eagle Scout special, for example.)

Tricky insight seems to be not the only way of getting a desired result in mathematics. Naturally a question arises. What are the ways, what are the different modes of thought employed by mathematicians enabling them "to crack" problems? Can we correspond a certain result to a certain kind of mathematical reasoning?

Donald E. Knuth, Professor of Computer Science at Stantford University is best known as the author of *The Art of Computer Programming*, a series of reference books. He has also developed new methods of mathematical typography and is well-known all over the world as a creator of TEX. In his article, published in *The American Mathematical Monthly* titled *"Algorithmic Thinking and Mathematical Thinking"* he makes an attempt to analyse the role of an algorithm in mathematics considering some simple examples of mathematical reasoning. Below are two fragments from this article where he analyses two kinds of mathematical reasoning:

I. «In *"A Survey of Mathematics"* edited by A. D. Aleksandrov et al., we find that page 100 is the chapter on Analysis by Lavrent'ev and Nikol'skiĭ. It shows how to deduce the derivative of the function $\log_a x$ in a clever way:

$$\frac{\log_a(x+h)-\log_a x}{h}=\frac{1}{h}\log_a\frac{x+h}{x}=\frac{1}{x}\log_a(1+\frac{h}{x})^{x/h}.$$

The logarithm function is continuous, so we have

$$\lim_{h\to 0}\frac{1}{x}\log_a(1+\frac{h}{x})^{x/h} = \frac{1}{x}\log_a \lim_{h\to 0}(1+\frac{h}{x})^{x/h} = \frac{1}{x}\log_a e,$$

since it has already been proved that the quantity $(1+1/n)^n$ approaches a constant called e, when n approaches infinity through integer or noninteger values. Here the reasoning involves formula manipulation and an understanding of limiting processes.»

II. «Struik's *"Source Book in Mathematics"* quotes authors of famous papers written during the period 1200–1800 A. D. Page 100 is concerned with Euler's attempt to prove the fundamental theorem of algebra, in the course of which he derived the following auxiliary result: "*Theorem 4. Every quartic polynomial* $x^4 + Ax^3 + Bx^2 + Cx + D$ *with real coefficients can be factored into two quadratics.*"

Here's how he did it. First he reduced the problem to the case $A = 0$ by setting $x = y - \frac{1}{4}A$. Then he was left with the problem of solving $(x^2+ux+\alpha)(x^2-ux+\beta) = x^4+Bx^2+Cx+D$ for u, α, and β, so he wanted to solve the equations $B = \alpha+\beta-u^2$, $C = (\beta-\alpha)u$, $D = \alpha\beta$. These equations lead to the relations $2\beta = B + u^2 + C/u$, $2\alpha = B + u^2 - C/u$, and $(B + u^2)^2 - C^2/u^2 = 4D$. But the cubic polynomial $(u^2)^3 + 2B(u^2)^2 + (B^2 - 4D)u^2 - C^2$ goes from $-C^2$ to $+\infty$ as u^2 runs from 0 to ∞, so it has a positive root, and the factorization is complete.

(Euler went on to generalize, arguing that every polynomial of degree 2^n can be factored into two of degree 2^{n-1}, via a polynomial of odd degree $\frac{1}{2}\binom{2^n}{2^{n-1}}$ in u^2 having a negative constant term. But this part of his derivation was not rigorous; Lagrange and Gauss later pointed out a serious flaw.)

When I first looked at this example, it seemed to be rather "algorithmic", probably because Euler was essentially explaining how to take a quartic polynomial as input and to produce two quadratic polynomials as output. Input/output characteristics are significant aspects of algorithms, although Euler's actual construction is comparatively simple and direct so it doesn't exhibit the complex control structure that algorithms usually have. The types of thinking involved here seem to be (a) to reduce a general problem to a simpler special case (by showing that A can be assumed zero, and by realizing that the resulting sixth-degree equation in u is really a third-degree equation in u^2); (b) formula manipulation to solve simultaneous equations for α, β, and u; (c) generalization by recognizing a pattern for the case of 4th degree equations that apparently would extend to degrees 8, 16, etc.»

Questions:

1. Could you think of some mathematical results you know and analyse them in the manner D. E. Knuth did that in his article?

2. What other types of mathematical reasoning have you found?

3. Could you think of some other results in which the author employs mathematical reasoning similar to that described in the fragments from the article cited above?

Unit 4

In the Introductory unit we considered three problems every student is facing while learning a foreign language:

1) how human beings perceive foreign languages;
2) the importance of making correct choices among the words;
3) the importance of speaking and writing grammatically.

We all learn languages to communicate, to share our thoughts and ideas with other people, to inform them about our personal contributions to particular branches of human knowledge.

In this unit you will read an article written by Reuben Hersh, the American mathematician, and published in *The Mathematical Intelligencer.* The article deals with the problem how to use the acquired knowledge of the subject matter to produce a research and how to write about it in English. The author shares his own experience and his views on the matter. The first part is about how to do research, the second one how to write it.

Reading I

Task 1.

a) Read the title, the subtitle and the list of key-words given below:

to deal with a topic; to get the idea; to find your problem; to have an "adviser", "field" or "area"; thesis; partial solution; strategy; to be an expert on . . . ; to have speed and stamina; to work on the problem; the deficiency in your education; to look at journals; outside your field; to behave in a non-standard way; to spot an anomaly; unrelated results; unnoticed, unexploited regularity; to figure out; generalizations, specializations, and extensions of an idea; to have a result on . . . ; the way to go; to acquire a reputation; a special case; to require a new idea; to keep sth. for a dissertation problem; to underrate sth. as . . . ; to yield formulas; to bring a theorem down to; connection with probability or p.d.e.; unrelated fields or methods or results; to know about different areas; to complete proofs.

b) Make sure you know the meanings of the key words. Let them help you in formulating the answer to the question:

   What will your strategy be in case your scientific adviser has already told you to work on some particular problem?

c) Compare your answers with those given by your classmates and tell what strategies are acceptable or non-acceptable. Give arguments for and against.

Task 2. Read the text.

HOW TO DO AND WRITE MATH RESEARCH

Many experienced researchers could write a better article on the topic. But they didn't write this, so I did. This advice is for the newcomer, the beginner, who may have cried in the night, "How the heck do you do math research, anyhow?"

I deal separately with two topics.

How do you do it?

How do you write it?

How Do You Do Research? Where do you get the idea? Or, as it's often put, where do you find your problems? There are several places, some worse than others.

Let us assume you already have an "adviser" and a "field" or "area," and your adviser has already told you that this year's hot problem in your area is say "the Uniqueness Problem." Maybe your thesis was a partial solution — uniqueness subject to Condition A. Your first publication!

What next?

1. One popular strategy is, chip away at Condition A. In your next paper, weaken it to Condition A'. And then Condition A" for the paper after that. You'll quite possibly become known as an expert on weakening Condition A.

2. Another idea is to keep your eye on the Uniqueness Problem itself. Half a dozen other hot shots and sharpies like you are already in the race. Keep up with them by e-mail or face to face. See how to strengthen X's new trick by simply refining his metric and then bringing in Y's old trick from last year. Write it up fast, to get it out before Z.

If you have speed and stamina, you may become known as one of the active young generation working on the Uniqueness Problem.

3. There are still other ways to go. You may struggle to remedy the deficiencies in your education, which you only now recognize. You may start to look at journals outside your field. If you behave in this non-standard way, you will occasionally spot an anomaly. A curious parallel between seemingly unrelated results, or an unnoticed, unexploited regularity.

Figure out what's going on. You'll end up with a publication, even several publications. You may then notice a crowd of eager youngsters peeking over your shoulder, looking for generalizations and specializations and extensions of your idea.

4. Generalization. A much-traveled high road to publication. Professor Q has a result on L^p-spaces. Generalize it to abstract Banach space. Then again, to Fréchet spaces. Then perhaps still again, even to Hausdorff spaces. Three solid papers in just one month. If you had been thoughtless, you could have done Hausdorff in the first place. But that would have been only one paper. I warn

you — this is not the way to go! You'll acquire a life-long reputation as a trifler and nose-picker.

Before you generalize, ask two questions. Does the generalization include at least one interesting special case that wasn't already covered? Does proving the generalization require a new idea, not standard in the generalized context? If the answer to both is No, keep it for a dissertation problem for your first marginal, weak student.

5. Specialization is underrated as a research tactic. If Professor Y has a nice theorem on Banach space, does bringing it down to L^p yield some surprising concrete formulas, or some unexpected connection with probability or p.d.e.?

Of these five roads, linking hitherto unrelated fields or methods or results is the one most apt to be a winner. It does require you to know a little about two different areas.

If you like to hide in your office till your proofs are all complete and then astonish your colleagues, you're at a serious disadvantage. Talking to others can be helpful. It may be hard to find anybody who'll listen. One way is to find somebody else who's also looking for somebody to listen. She listens about your sub-von Neumannian hyper-loops, you listen about her semi-Markovian submartingales.

Reuben Hersh

Vocabulary

Task 3. Make a list of all the mathematical terms you came across in the text. Try to define them.

Example:

probability — likelyhood, or chance, that an event will occur, often expressed as odds, or in mathematics, numerically as a fraction or decimal. In general the probability that n particular events will happen out of a total of m possible events is n/m. A certainty has a probability of 1; an impossibility has a probability of 0. Empirical probability is defined as the number of successful events divided by the total possible number of events.

Task 4. Below are the words taken from the text. Try to guess their meaning from the context in which they are found. In each case choose one of the three answers which you think best expresses the meaning.

refine — (line 24)

(a) to polish, to improve in accuracy and excellence, to suggest the process of separating what is valuable from what is dross;
(b) to fight against; to oppose by force;
(c) to make stable or firm.

stamina — (line 27)

(a) power over men or things;
(b) to have a well-wished friendliness or concern for the needs and desires of other people;
(c) power of endurance, staying power, vigor.

remedy — (line 29)

(a) to recover from ruin or decay;
(b) to overcome a defect or undesirable state of affairs not necessarily having to do with health;
(c) to adopt an idea or interpretation in the face of incomplete evidence or uncertainty.

deficiency — (line 30)

(a) lack of something that is required to accomplish a given goal or purpose;
(b) dedication to the task;
(c) an underlying form that is not necessarily observable by a glance.

peek — (line 37)

(a) to look forward exclusively to some positive outcome;
(b) to steal the words, ideas, etc. of another and use them as one's own;
(c) the act of looking with an attempt to see what is hidden or concealed.

trifler — (line 46)

(a) one who makes war against his own country or gives aid to its enemies;
(b) a person doing something so trivial as to be unworthy of notice;
(c) sizable collection of people.

marginal — (line 51)

(a) is applied to persons who do not accomplish things quickly;
(b) peripheral, pointing to a small degree of value, usefulness or importance;
(c) the word is used to describe things that happen in the everyday course of events and are accepted as normal and natural rather than as novel or strange.

hitherto — (line 57)

(a) up to now, to this time;
(b) in favor of;
(c) during.

apt — (line 58)

(a) childishly frank;
(b) suitable; prompt;
(c) favoring democratic and progressive ideas.

Task 5. Read the following list of word combinations:
this years's hot problem; chip away of Condition A; hot shots and sharpies; are already in the race; X's new trick; a crowd of eager youngsters peeking over your shoulders; a much-traveled high road to publication; a trifler and nose-picker; marginal weak student.

The author of the article is speculating about a very serious and essential subject, that is, research strategy and tactic. He seemingly does not want to be instructive. Read the text one more time and think of more neutral equivalents for the word combinations listed above.

Task 6. Supply the necessary prepositions to make the sentences. Check against the text.

I deal separately ... two topics. This year's hot problem ... your area is say "the Uniqueness Problem." Your thesis was a partial solution ... uniqueness subject ... Condition A. Weaken Condition A ... Condition A'. You'll become known as an expert ... weakening Condition A. Keep up ... your colleagues ... e-mail or face ... face. You may become known as one ... the active young generation working ... the Uniqueness Problem. You may start to look ... journals ... outside your field. If you behave ... this non-standard way, you will occasionally spot an anomaly. Generalization is a much-traveled high road ... publication. You can publish three solid papers ... just one month. You could have done Hausdorff ... the first place. Keep generalization ... a dissertation problem ... your first marginal, weak student. ... these five roads is the one most apt to be a winner. You are ... a serious disadvantage. Talking ... others can be helpful.

Task 7.

a) Find the sentences in the text having a modal verb as a part of a predicate. The list of the predicates is given below. Write the sentences down.
Could write; may have cried; may become known; may struggle; may start; may notice; could have done; would have been; can be helpful; may be hard.

b) Identify the meaning of each modal verb in the sentences. Is it:

- obligation, necessity;
- supposition, doubt, uncertainty;
- ability, possibility;
- permission, prohibition;
- polite question or request;
- dissaproval, reproach;
- promise, threat?

Task 8.

a) Below is the list of **prepositional phrases** and **phrasal verbs** you have found in the text. Identify among them prepositional phrases and phrasal verbs, arrange them into two columns. (If you have some problems consult grammar notes in Unit 3.)
*Write **on** the topic; cry **in** the night; deal **with** topics; uniqueness subject **to** Condition A; chip **away at** Condition A; weaken it **to** Condition A; keep your eye **on** the problem; keep **up with** them; bring **in** Y's old trick; write it **up** fast; get it **out before** Z; look **at** journals **outside** your field; behave **in** this non-standard way; figure **out** what's going **on**; end **up with** a publication; peek **over** a shoulder; look **for** generalization; have a result **on** L^p-spaces; generalize it **to** abstract Banach space; keep it **for** dissertation; bring it **down to** L^p; hide **in** your office; you're **at** a serious disadvantage; talk **to** others; look **for** somebody; listen **about** your submartingales.*

b) Find equivalents for phrasal verbs.

Task 9.

a) Read the following two sentences and translate them into Russian.
1. *If you have speed and stamina, you may become known as one of the active young generation working on the Uniqueness Problem.*
2. *If you had been thoughtless, you could have done Hausdorff in the first place. But that would have been only one paper.*

b) Both sentences express a condition. Identify which one is:

— true in the present or future;
— untrue (contrary to fact) in the present;
— untrue (contrary to fact) in the past.

(If you have problems consult the grammar book, pp. 34–35.)

Discussion of facts, ideas, and concepts

Task 10. Answer the following questions.

1) Does the author know a good place where to find your problem?
2) What is the problem your scientific adviser told you to be hot this year?
3) What can make you become known as an expert on weakening Condition A?
4) Does the author recommend to keep up with colleagues or to work individually?
5) What is the condition to become known as one of the active young generation working on Uniqueness problem?
6) How can one eliminate the deficiencies in one's education?
7) How often can one spot an anomaly?
8) What is a much-traveled high road to publication?
9) What questions should one ask before trying to generalize?
10) What is one of the ways in research to yield some surprising concrete formulas or some unexpected connection with probability or p.d.e.?
11) Which of the five roads is the one most apt to be a winner?
12) Why does the author think one is at serious disadvantage while working on proofs solely and what is the advantage of talking to others?

Read each paragraph separately, find the key idea in it. Make an outline of the text. Put the text aside and retell it consulting only your outline.

Task 11.

a) The list given below furnishes you with words and phrases supposed to help you in discussion of your personal ideas and views on research process. Use them in the sentences of your own.
To have an adviser; to have a "field" or "area"; to have a problem; first publication; to keep your eye on a problem; to keep up with sb by e-mail or face to face; to strengthen sb's new finding; to refine sth in sb's work; to bring in sth; to get a publication out before sb; to struggle to remedy the deficiencies in sb's education; to recognize the deficiency; to look at journals; outside sb's field; to behave in a non-standard way; to spot an anomaly; to spot a curious parallel between sth; seemingly unrelated results; unnoticed unexploited regularity; to figure out what's going on in a field or area; to end up with a publication; to look for generalization, specialization, extension; to generalize sb's result to ... ; to include a special case that wasn't already covered; to provide the generalization; to underrate sth; to require a new idea; to keep an idea for a dissertation problem; to have a theorem on ... ; to bring a theorem down to ... ; to yield some concrete formulas; to yield some unexpected connection with ... ; to link hitherto unrelated fields or methods or results; sth requires sb to know about sth; to complete the proof.

b) Look through the list again. Tell the class:

1) What is the area or field you are interested in mostly?
2) Whom would you like to see as your scientific adviser?
3) What is a particular problem in this field which seems to be hot at the moment?
4) What are the methods you are going to exploit in the solution of your problem?
5) What are the journals, books and papers you are going to look at to remedy the deficiencies in your education?

6) Will you generalize, specialize or extend the ideas of your scientific adviser in your first work?
7) What other areas different from the one you are working in will be required to know?
8) Whom are you going to talk to while working on your proof? Is there anybody whose advice seems to be helpful to complete the proof?
9) How soon are you going to end up with your first publication?

Reading II

Task 12. Consider the introductory text and two quotations from the authors who are recognized specialists on composition.

The process of writing is considered to be troublesome for most of us. Even if you have a clear idea on what you are going to write you will have problems in designing the paper, in choosing the correct words, in grammar and in style. A writer must use his good sense and good taste, and adopt for his own composition those principles that experience shows to be most effective for his purposes. Scientific writing, its style and manner must fit the *subject matter,* the *reader,* and the *writer.* It must satisfy practical requirements:
First, it **must facilitate rapid reading.**
Second, it **must convey the exact meaning.** There must be no ambiguity or uncertainty in the writer's message.
Third, it **must be objective.** The writer's emphasis is seldom on himself: almost always it is on what is true, what happens, what has been observed.
Fourth, it **must be clear for later reference.** The paper is supposed to be designed for the future convenience of specialists.

"Many persons who have the reputation of being sharp and clever, and whose conversation is by no means commonplace, are utterly helpless when the pen is placed in their hand. They have not acquired, through practice, that power of concentration which is necessary for the fixing of an idea ... But it is an art which may, with proper practice, be acquired ... and the one thing most needful is that rules be ... acquired through practice. Also it must be made a thing of habit."

W. E. Aytoun, *Lectures.*

"Writing is, for most, laborious and slow. The mind travels faster than the pen; consequently, writing becomes a question of learning to make occasional wing shots, bringing down the bird of thought as it flashes by. A writer is a gunner, sometimes waiting in his blind for something to come in, sometimes roaming the countryside hoping to scare something up. Like other gunners, he must cultivate patience: he may have to walk many covers to bring down one partridge."

W. Strunk, *The Elements of Style.*

Task 13. Consider the introductory text and two quotations. Answer the following questions, compare your answers with those of your classmates. Discuss them in the class.

1) Is the process of writing troublesome or easy for you?

2) Do you work from a suitable design before beginning to compose something?

3) Do you follow a scheme or an outline while writing on some subject or do you rely upon impulse and emotion rather than design? Does it depend on the kind of writing?

4) What do you think about the following?

   "But even the kind of writing that is essentially adventurous and impetuous will on examination be found to have a secret plan: Columbus didn't just sail, he sailed west, and the new world took shape from this simple and, we now think, sensible design."

   P. Strunk

5) Do you have any experience in scientific writing?

6) What do you think about the following?

   "If the writer's statements are so worded as to mislead, confuse, or produce false impressions, his ability as an investigator amounts to little. Exactness of statement is just as necessary as accuracy in research."

   H. F. Graves

7) Is it important for a writer to adapt to a reader? Should a writer be well aware of the necessity of making his scientific paper fit the interests, peculiarities, knowledge, and desires of his reader?

8) Do you think answers to the following questions are helpful to differentiate your reader?

   a) What is his education, specific training and experience?
   b) How much information does he have on this subject?
   c) What information does he want?

Task 14. Read the second part of the text *How to do and write math research.*

Writing It. Your first big decision is: are you writing to be understood, or to not be understood?

In a letter to Florimond De Beaune, Rene Descartes wrote, on February 20, 1639, " ... in the case of the tangents, I have only given a simple example of analysis, taken indeed from a rather difficult aspect and I have left out many of the things which could have been added so as to make the practice of the analysis more easy. I can assure you, nevertheless, that I have omitted all that quite deliberately, except in the case of the asymptote, which I forgot. But I felt sure that certain people, who boast that they know everything, would not miss the chance of saying that they knew already what I had written, if I had made myself easily intelligible to them. I should not then have had the pleasure, which I have since enjoyed, of noting the irrelevance of their objections."

Some mathematicians write so as not to be understood, without consciously recognizing that as their goal. Sleepwalking has its advantages. But since you're reading this paper, I presume you want to know what you're doing.

Some tips on how not to be understood, gleaned from the recent literature.

1) Don't explain why you're doing what you're doing, beyond a cryptic remark like “The Uniqueness Problem is related to the construction and classification problems for sub-von Neumannian hyper-loops.”

2) Don't explain in any meaningful way what has already been done. Do give references — at least 30, mostly in French.

3) Avoid natural language. Anything that can be said in English can be said in symbols, if you make an honest effort.

4) Don't repeat anything already stated in any of your references. Not many readers will track them down in the library, especially if your references aren't in the library.

5) Use many different type faces. Gothic is good. But double and triple subscripts may be rejected by the printer.

6) Write “it's easy to see” and “a short calculation shows” and ”it follows immediately” and “by a well-known argument of Nicomachus” as often as you dare.

So much for that.

What if you want to be understood?

Writing to be understood is more trouble than writing not to be understood. Over your lifetime, it will cut down your “productivity.” There's a popular belief that understandable writing is bad for your reputation. “If I can understand it, it must be trivial.” Don't be intimidated by this belief. Defy it. Mathematicians are grateful to mathematicians who write understandably. They are understandably more likely to read understandable papers.

Writing understandably means, of course, *not* following the practices recommended above for being not understood.

A good way to write an understandable paper is to have one central idea. State it at the beginning. Carry it out in successive stages. Point out as you go that you're carrying out the central idea you stated at the beginning.

Your work may not have such a unified, coherent character. Maybe you did several interrelated things, all relevant to the Uniqueness Problem. Then make a clear separation of your paper into parts, each of which is unified. In the introduction, explain why you have organized the paper as you have. Where different sections of the paper are connected, discuss the connection in *both* places. Taking up a few lines of print to save your reader a few minutes of trouble is legitimate.

If you want to omit an argument or a calculation, give a short outline of what you're omitting, so that an interested reader really has a chance to fill it in.

Use the highest standards of composition of which you are capable. Never a pronoun whose reference is fuzzy in the slightest. Short words rather than long. Concrete nouns and verbs rather than abstract. Active voice rather than passive. Short, grammatical sentences. Paragraphing according to the flow of ideas. Be consistent in using the past tense or the present, in having as a subject "you" or "we" or "one."

If you use a foreign word, do tell us what it means.

When you're finished, put your paper away for a week. Reread it. *In each sentence*, look for unnecessary words. Cross them out.

In each paragraph, look for unnecessary sentences. Cross them out.

Look especially for unexplained terms and concepts. Explain them.

Put your paper away for another week.

Reread it. Correct it again.

Continue putting it away for a week, rereading it and correcting it, until it is perfect.

You've done your duty. Send it in.

Expect complaints and requests for more changes.

REUBEN HERSH

Vocabulary

Task 15.

a) Consider the list of the key-words. Make sure you know their meanings. Consult a dictionary. If you have a problem ask your teacher to help you.
To write to be (not to be) understood; an example of analysis; to leave out sth; to make the practice of the analysis; to make oneself intelligible to sb; irrelevance of the objections; to presume sth; problem is related to sth; meaningful way; to give references; to make an effort; to track the reference down in the library; subscript; to be rejected by sb; it follows immediately; to have one central idea; to carry out the idea in successive steps; a unified coherent character; interrelated things; sth relevant to sth; separation of paper into parts; to take up a few lines of print; to give a short outline; in the slightest; sth rather than sth; to be consistent in doing sth; unnecessary words; to do one's duty; complaints and requests for . . . .

b) Write sentences of your own with at least 10 of these words and phrases.

Task 16. Below are the words taken from the text. Try to guess their meaning from the context in which they are found. In each case choose one of the three answers which you think best expresses the meaning.

deliberately — (line 9)

(a) characterizes an action undertaken after weighing all the aspects of a situation, with caution and care involving rational process of decision-making;
(b) describes someone or something that differs from the ordinary or the usual;
(c) characterizes an action of bringing or coming together of several different elements to form a whole.

boast — (line 10)

(a) to overcome an opponent in a competition or struggle;
(b) to refer to the rejection of a previous statement by argument or evidence;
(c) self-important and tasteless pointing out one's own successes.

consciously — (line 16)

(a) suggests a light lack of seriousness in manner;
(b) inappropriate pseudo-elegance of manner;
(c) having knowledge of the existence or fact of something, mind's registing of a sensation, perception or state of affairs.

glean — (line 19)

(a) to collect with patient labor, to pick up here and there;
(b) to move gently or smoothly;
(c) to print and issue books for sale.

cryptic — (line 22)

(a) a parasitical and self-seeking relationship to someone in a superior position, rather than an attitude of sincere respect;
(b) an intelligent and objective approach to problems or behavior;
(c) refers to things kept secret or hidden or that have been deliberately made remote from easy understanding.

intimidate — (line 43)

(a) to send a hand-released projectile through the air by a swing of the arm;
(b) to manipulate someone by using his own fear or weakness against him as a psychological weapon;
(c) to point to a negative emotional response to someone or something.

defy — (line 43)

(a) implies active opposition, to resist authority;
(b) to judge and form an opinion of the value;
(c) to remove one's residence from one place to another.

legitimate — (line 59)

(a) refers to something present in great quantities or something frequently met with;
(b) is applied to anything that is recognized by custom or in popular usage as conforming to established rules or standards;
(c) refers to things that mutually exclude each other, so that both cannot exist in the same object at the same time.

fuzzy — (line 64)

(a) unclear or confused, lacking details;
(b) showing politeness and attention to ladies;
(c) applied to persons motivated chiefly by a desire for profit.

consistent — (line 68)

(a) lying upon the ground, floor, or other surface;
(b) suggests agreement or harmony between things or between details of the same thing;
(c) applies to anything which has a strong, distinctive smell, whether it is pleasant or not.

Task 17. Supply the necessary prepositions to make the sentences. Check against the text.

1) I had made myself easily intelligible ... the people who boast that they know everything.

2) Some tips ... how not to be understood.

3) The Uniqueness Problem is related ... the construction and classification problem.

4) Don't explain ... any meaningful way what has already been done.

5) Anything that can be said ... English can be said ... symbols.

6) ... your lifetime, writing to be understood will cut down your productivity.

7) You did several interrelated things, all relevant ... the Uniqueness Problem.

8) Never use a pronoun whose reference is fuzzy ... the slightest.

9) Be consistent ... using the past tense or the present, ... having as a subject "you" or "we" or "one".

10) Put your paper away ... a week, then ... another week.

Task 18. Look at the table below. The phrasal verbs in column *A* have all appeared in the texts in Reading I and in Reading II. Match a phrasal verb in *A* with its equivalent in *B*. If necessary consult the text or a dictionary.

A	B
to chip away at	to remove sth. from a place where it is fixed
to keep one's eye on sth.	to cease to consider sth.
to keep up with sb.	to add (*usually* words), to complete sth.
to write sth. up	to fulfil or perform sth.
to get sth. out	to look after something and make sure that it is safe
to figure sth. out	to draw a line through (writing) to remove it
to end up	to reduce the size of something
to look for	to manage to go or learn as fast as someone
to bring down	to reduce
to leave out	to think about a problem or situation until you find the solution
to track down	to gradually make something less effective or destroy it
to cut down	to succeed in producing or publishing something
to carry out	to try to find something
to point out	to finish

to take up	to write a report, article etc using notes that you made earlier
to fill in	to fail to consider something
to put away	to find (someone or something) by or as by hunting
to cross out	to show, to explain, to draw attention to sth.

Grammar notes and grammar tasks

Task 19.

1. a) Below is a list of predicates organized in columns under the names: Perfect forms, Passive forms and Progressive forms. Find the sentences in the text having these verb forms as predicates.

Perfect forms	Passive forms	Progressive forms
have given	be understood	are writing
have left out	could have been added	you're reading
could have been added	is related	you are doing *(3 times)*
have omitted	has already been done	are carrying out
had written	can be said	are omitting
had made	may be rejected	
should not have had	don't be intimidated	
have enjoyed	is unified	
has already been done	are connected	
have organized	are finished	
have done		

   b) Review the grammar book, pp. 23–27. Make sure you know why these tense forms are used in these sentences, explain why. Make an example of your own with each tense form to prove your competence in this grammar area.

2. The sentences given below have at least one modal verb. Identify the meaning of each and tell what feelings or attitudes the author experiences to each particular statement which is shown by the modal verb. Consult your grammar book, pp. 28–31.

1) ... I have left out many things which *could* have been added so as to make practice of the analysis more easy.
2) I *can* assure you, nevertheless, that I have omitted all that quite deliberately ...
3) ... certain people ... *would* not miss the chance of saying that they knew already what I had written ...
4) I *should* not then have had the pleasure ... of noting the irrelevance of their objections.
5) Anything that *can* be said in English *can* be said in symbols.
6) But double and triple subscripts *may* be rejected by the printer.
7) If I *can* understand it, it *must* be trivial.
8) Your work *may* not have such a unified coherent character.

Task 20. Find in the text the sentences with the phrases given below. Identify the function of each *ing*-form in the sentences. Translate them into Russian. (In case of uncertainty consult the grammar notes in Unit 1.)
A chance of saying; a pleasure of noting; without recognizing; sleep-walking has its advantages; writing to be understood; understandable writing; writing understandably; not following the practices; practices for being not understood; at the beginning; taking up a few lines of print ... is legitimate; paragraphing according to the flow of ideas; consistent in using and in having; continue putting your paper away; rereading it and correcting it.

Grammar notes 1

A sentence can not only be expanded, it can also be condenced. Infinitives (non-finite forms of the verbs) play an important part in making a sentence as compact as possible. Complex Subject and Complex Object structures have an advantage of compactness aiming at eliminating the number of subordinate clauses in a sentence making a discourse shorter in words. Consider two sentences from the text.

E.g. It does require *you to know* a little about two different areas. (Complex Object)
They are understandably more likely *to read* understandable papers. (Complex Subject)

For the academic writing compactness is a desired quality of speech as far as the printers generally place a limitation on the length of papers supposed to be published. The structures Complex Subject and Complex Object have no analogy in Russian. Consider the translation of the two above given sentences:
Это обстоятельство, однако, требует, чтобы вы имели представление об этих двух областях знания.
Понятно, что скорее всего они будут читать те статьи, которые понимают.

The conventional way of translating the sentences with Complex Subject into Russian is to translate them as sentences with subordination: Говорят, что ... ; Известно, что ... ; Вероятно, что ... ; Кажется, что ... .

Complex Object is rendered into Russian by an object clause.

Task 21. Translate the following sentences from English into Russian. Identify Complex Subject.
1. Techniques are known to be used for the prediction of an earthquake and should involve no complex new equipment. 2. This is particularly the case where the science in question is historical and where the objective necessity of scientific laws is thought to govern historical process. 3. Powder methods which are likely to be applied for any purpose except identification of the substance have been suggested as early as in the last century. 4. It would be impractical to attempt to solve this problem for the whole British coastline, but some of the existing reserves are known to be of exceptional scientific interest and would provide excellent bases for such solution. 5. The necessity for a new reconstruction of logic became ever more pressing when certain contradictions were noticed in the realm of mathematics, which soon proved themselves to be of general, logical nature. 6. Today there are 10 well-characterized human diseases that are known to be caused by the excessive accumulation of lipids in tissue cells. 7. Titan, the largest and brightest of Saturn's satellites, is the only moon in the solar system known to have an atmosphere. 8. Shear instability is one form of process believed to stir the ocean in regions where high frequency internal waves propagate between the layers of significantly different density. 9. Temperature control is expected to be achieved by altering the atmosphere in the reaction chamber. 10. The part of physics

which is believed to involve chemistry is already widely known. 11. Calculation can still, of course, be used, but several suggestions have been made which seem to offer more possibilities of easing the work of the initial stages of a structure determination. 12. In this section the emphasis must be placed upon those parts of the constitution which appear to be of current importance. 13. The rays are supposed to be diffracted by the crystals. 14. The circumstances are such that no reasonable person would be expected to choose the other alternative. 15. The statistical approach has become of late very popular in linguistics, not only because of the precision and objectivity which it is held to guarantee, but also because language is a mass phenomenon “par excellence”, which seems to invite this kind of treatment.

Task 22. Translate the following sentences from English into Russian. Identify Complex Object.
1. We find the reaction to proceed smoothly in the presence of an acid catalyst. 2. Nobody expects this problem to be solved within such a short period of time. 3. We are justified in considering the fundamental categories of cultural life to be essentially the same in all societies. 4. We are forced then to assume this reaction to proceed rapidly. 5. We know such expressions to have been resolved into real and imaginary parts. 6. We know measurements of the neutron total cross section to have been made by Darden. 7. We know professor K. to have published some observations on the means of communication employed by bees. 8. Let us consider these ideas to be applicable to Mars. 9. Mathematicians believe the solution of the equations involved to be reduced to a sequence of basic operations: addition, subtraction, multiplication, division, square root, and possibly others, depending on the machine. 10. Many authors have considered the final response to signals to be based on an algebraic sum of the stimulus effects. 11. Every specialist in this field of science knows this conclusion to be supported by evidence from sources in the literature as well as by the current study. 12. We have not neglected, but rather have shown the existence of Gribov — Pomeranchuk poles to be irrelevant. 13. This curve, in connection with other curves, is simply telling us to expect an event

of major cosmic significance to take place in the next fifty years. 14. Such a distribution can be derived by assuming the solid to be a homogeneous and isotropic medium. 15. We expect it to be generally recognized that the eventual solution of the energy problem depends not only on developing alternative sources of energy but also on devising new methods of energy conversion. 16. Descartes is not entirely right in expecting algebraic techniques to supply the effective methodology for working with curves. 17. Let us assume an airplane to be approaching an observer with a velocity equal to one half the speed of sound. 18. More recent theorists are inclined to consider much of the information in the brain to be received and stored by continuous line or analog mechanisms which are very difficult to measure and describe.

Grammar notes 2

In expressions 'Have a seat', 'Be careful', 'Come here' the verb forms can be called imperatives. The imperative has exactly the same form as the infinitive wihout 'to'; it is used for giving orders to do things. In an imperative the subject is usually unstated. Only the predicate is stated. If the subject is absent, we assume it is you, the person or persons addressed.

Note the following points.

1) The imperative can be used with subject if it is necessary to make it clear who is being spoken to.

   E.g. Somebody answer the question. Nobody move. Mary spell the word on the blackboard, the rest of you do it in the note-books.

   'You' before an imperative can suggest anger.

   E.g. You get out.

2) An imperative can be more emphatic by putting 'do' before it.

   E.g. Do sit down. Do be quite. Do forgive me I did not mean to interrupt.

3) Negative imperatives are constructed with 'do not (don't)'.

   E.g. Don't worry. Don't be a fool.

4) 'Always' and 'never' come before imperatives.

   E.g. Always remember to smile. Never speak to me again.

5) In commands and requests addressed to the third person or persons the form Let... + Infinitive is used.

   E.g. Let us go. Let him finish. Let Mary do it herself. Let us not get angry.

Task 23. Read the text again and write all the sentences with Imperative down. Identify among them:

— where the author

  a) gives order,
  b) makes suggestion,
  c) encourages to do things;

— emphatic imperative;

— negative imperative;

— addressed to the third person.

Why do you think in the paragraph (lines from 64 to 67) there is neither subject nor predicate? Reconstruct the sentences introducing the appropriate predicate.

Discussion of facts, ideas, and concepts

Task 24. Find the answers to these questions in the text.

1) What are the two intentions in writing a paper on academic subject?
2) Do some mathemiticians write so as not to be understood consciously recognizing that as their goal?
3) What cryptic remark will help you to avoid the explanation why you are doing what you are doing?
4) How can one avoid the explanation of what has already been done in his field?
5) What is the alternative of using natural languages?
6) What is your advantage in case you don't repeat anything already stated in any of your references?
7) How can many different type faces affect the printer?
8) What is one of the useful tools of avoiding explanations?

9) How does writing to be understood affect your "productivity"?
10) What should not be supposed to intimidate the writer and what does the author recommend to defy?
11) How is the central idea advised to be developed?
12) What is the case when a clear separation of your paper into parts is essential? How should one organize a paper like this?
13) What do you have to do if you want to omit an argument or a calculation?
14) Will you send the paper immediately after you have finished it?
15) What are the recommended steps in working on your paper after you have finished it?

Task 25. Read and translate the quotation from the letter written by René Descartes to Florimond De Beaune of February 20, 1639. Discuss:

1) In writing the paper Descartes employed a certain strategy. He deliberately omitted some details. Have you understood why he did so? Why did not he want to be easily intelligible to some people?

2) Think of some motives for a researcher to write not to be understood. List them out. Compare them with those of your classmates. Discuss them in the class.

3) Think of some advantages for a researcher to be understood. List them out. Compare them with those of your classmates. Discuss them in the class.

4) 'Use the highest standards of composition' is the citation from the author. What do you know about these standards. Read at home the first three chapters from the book М. С. Корнеева, Т. К. Перекальская. *Учебное пособие по развитию навыков аннотирования и реферирования.* Discuss them in the class.

Appendix

Just for fun

The article you are going to read in this section was published in *Discover* by Judith Stone. It is titled *LEISURE PURSUITS. (HOW SCIENTISTS RELAX)*. If you like jokes, moreover if you like to know that scientists and mathematicians let their unconscious work on a frustrating problem while they dig tunnels, exercise, tell jokes or relax in other ways, you will surely read it. Note down any funny story you know about scientists or mathematicians. Tell it in the class.

LEISURE PURSUITS (How scientists relax)

When Seymour Cray, designer of the world's fastest, smartest computers, reached a creative impasse, he'd hit the dirt: for several years he dug a tunnel eight feet high and four feet wide that ran from his rural home toward the shore of Lake Wissota, in western Wisconsin. The manual labor cleared his mind, the 68-year-old Cray told John Rollwagen, former chairman of Cray Research. And while he was shoveling, Cray said, woodland elves slipped into his office and solved his problems. Rollwagen shared the whimsical story with the press, apparently believing that this feat of clay would humanize the elusive genius. A company spokesman told me the inventor did some of his most inspired troubleshooting in the tunnel. (What better place to think deep thoughts than underground?)

After hearing about Cray, I started wondering what diversions other scientists choose when they encounter a mental roadblock.

We know that the nineteenth-century French mathematician Jules-Henri Poincaré traveled when he was stuck on a problem; a change of scene more than once led to what seemed the spontaneous untangling of a knotty problem. He described this form of divertissement and its satisfying results in a celebrated lecture before the Société de Psychologie. (He began with an apology I find especially charming: "I beg your pardon; I am about to use some technical expressions, but they need not frighten you, because you are not obliged to understand them.")

Poincaré was working on his famous theory of the Fuchsian functions (which need not frighten us, because we are not obliged to understand it). He'd solved most of the problem one night in a caffeine rush; then he hit a dead end.

"Disgusted with my failure, I went to spend a few days at the seaside and thought of something else. One morning, walking on the bluff, the idea came to me with ... suddenness and immediate certainty, that the arithmetic transformations of indeterminate ternary quadratic forms were identical with those of non-Euclidean geometry."

Perhaps you were otherwise employed when you first realized that the arithmetic transformations of indeterminate ternary quadratic forms were identical with those of non-Euclidean geometry: playing the ocarina, maybe, or organizing your Three Stooges memorabilia, or digging a tunnel. The point is, some head-clearing pastime helped you solve your problem. What might have seemed to the untutored a frivolous and dilatory act was actually a vital component of creation.

In 1926 the political and social scientist Graham Wallas delineated the four stages of creative thought: preparation, or the accumulation of the background knowledge to solve a problem (Archimedes wasn't just any old guy sitting in the tub — he'd prepared for that moment of relaxation-mediated inspiration with a life of rigorous work and study); incubation, the time when you step back and let the idea simmer; illumination, the moment when the solution dawns, seemingly from nowhere; and verification, the hard proof that follows the shriek of Eureka!

The simmering period interests me most — what physicists and mathematicians do when they kick back. According to George Tremberger Jr., director of Barnard College's History of Physics Lab, Isaac Newton engaged in few leisure activities except gardening, and he hired someone to do the dirtiest work. René Descartes liked to stay in the sack until late morning, cogitating. Niels Bohr did crossword puzzles; George Gamow was a western-movie freak. Einstein relaxed with the violin, of course; he also loved sailing, which he called "the sport that demands the least energy."

Caltech physicist and Nobel laureate Murray Gell-Mann says that ideas may come when he's cycling, walking, or cross-country skiing. "And while I'm shaving too," he adds. (Women in physics will want to know whether legs count.) "Talking to people about anything, even about the problem, is also useful." "I once made a slip of the tongue during a lecture that led to an important discovery. It was in 1952, and I was trying to explain the properties of strange particles — strange because they were copiously produced but decayed slowly, in one ten-billionth of a second, which is slow for particle physics. I had had an idea for how to explain them, but it didn't work." During a visit to the Institute for Advanced Study at Princeton, some colleagues asked Gell-Mann to explain the failed idea. He was discussing the numbers that would solve the problem, which, according to conventional wisdom, would have to involve halves (we are not obliged to understand). He meant to say five halves but slipped and said one. "And I stopped and exclaimed, 'It would work!' Here was a solution I'd probably been chewing on for some time below the level of conscious thought."

Humor is a characteristic brain refreshment for the spiritual children of Pythagoras, says Temple University mathematician John Allen Paulos, author of Mathematics and Humor (soon to be a major motion picture with Steve Martin as Mathematics, Lily Tomlin as Humor, and Julia Roberts as And). "Pure mathematics and humor share tools and techniques," he says. "Because we take things literally in our work, we take words and phrases literally, which is often very funny." At Princeton in the 1930s, there was a fad among mathematicians for inventing jokes about mathematical methods for catching lions. For example:

The method of inversive geometry: We place a spherical cage in the desert, enter it, and lock it. We perform an inversion with respect to the cage. The lion is then in the interior of the cage, and we are outside.

Maybe you had to be there.

Adds Paulos, "Our work also predisposes us to appreciate various combinatorial manipulations like juxtaposition, recursion, and word reversal, or notions in logic, such as reductio ad absurdum or self-reference. For example, Q: 'Why do philosophers ask so many questions?' A: 'Why shouldn't philosophers ask so many questions?' Nonstandard models, which are useful in math, demonstrate that various conditions can be satisfied in more than one way. That leads to the 'What's black and white and re(a)d all over?' genre of joke — the unexpected answer ranging from a newspaper to a wounded nun." Paulos's favorite dumb math joke:

Mathematician: How do you spell Henry?

Unsuspecting Victim: H-E-N-R-Y.

Mathematician: No, H-E-N-3-R-Y. The three is silent.

Maybe you had 2-B there.

Some scientists, like physicist Melissa Franklin of Harvard and Fermilab, relax by doing more science. Franklin says that when a problem has fried her brain, she chills out by trying to solve other problems.

"At Fermilab, I'd come in on weekends and work on things for fun. For example, we were working on a proton-antiproton collider experiment, looking for the top quark. I build detectors, and I was getting interested in improving them using electronics. It was refreshing because nobody was pushing me to do it and there was no huge responsibility on my head."

Dr. Franklin! No horseshoes? No Yahtzee? "No, but some of us did a little experiment in the Harvard biology lab a couple of years ago that was enormously fun. It was wild and crazy, something you wouldn't want to put on your vita: a search for very massive protons." (Confidential to nonphysicists: Do you think that's anything like a snipe hunt?) “We were assuming that these protons, if they existed, came from the Big Bang and would be landing on the bottom of the ocean. So we tried to get water from the bottom of the ocean, from rocks and oil wells. We centrifuged and filtered the water; the idea was that heavy things would stay at the bottom. We built something that measures the density of a drop of water, and sat around dropping water into this density gradient. That was fun.”

“Oh, and I had a lot of fun recently with the electric pickle.”

As who of us has not! The electric pickle is an experiment that was a tremendous success in Franklin’s freshman electronics class. You go to a deli, see, and get a big kosher dill pickle, seven or eight inches long. Then you cut the cord off an old electric appliance and strip the ends to expose two or three inches of split wire. (Unplug it first.) Get two two- or three-inch nails, wrap one strand of wire around each nail, and stick the nails into the pickle. Then plug in the cord. “After about 10 seconds,” Franklin explains, “the pickle will light up, glowing and crackling. It’s really quite bright.” What happens is that the brine, which is a good electrical conductor, goes through chemical decomposition. It actually burns for about 45 seconds. “You can try it at home,” says Franklin, “but don’t touch the pickle.”

At some point in my informal survey, I was struck by how many more mathematicians than I would have expected — literally bunches, with a standard deviation of heaps — juggle. Persi Diaconis is a Harvard mathematician, statistician, and magician. (I like the ring of “Harvard magician.”) He has recently devoted several sessions of his seminar on algebraic combinatorics to the mathematics of juggling. He says that while he believes only 10 or so of the nation’s 20,000 mathematicians are after-hours magicians, perhaps 1,000 are jugglers, a number he considers statistically insignificant but that I consider astonishing. (Adds Diaconis, “I also know a lot of mathematicians whose passion in life is cheap detective novels — the worst sleaze, with lurid covers. They trade them among themselves, though they’d never own up to it.” He once served as book bagman between a famous Berkeley mathematician and a famous Stanford mathematician who, I suppose, couldn’t wait to send each other Blonde on a Tangent or Dial N for Nightmare [Where $N =$ Infinity]).

But we were talking about juggling. Follow the bouncing ball, and let's agree not to make any remarks about juggling figures; mathematical folks involved in the circus arts don't want to hear them any more than chef-accountants welcome comments about cooking the books.

Diaconis's friend Ron Graham is director of information-sciences research at Bell Laboratories, University Professor of Mathematics at Rutgers, and president of the American Mathematical Society. He is also past president of the International Jugglers Association.

"I like my leisure with unusual challenges that help me get a new perspective," he says. "Like trying to juggle three Ping-Pong balls using two Ping-Pong paddles instead of my hands. That helps me see things in a different perspective and gets my blood flowing."

Graham also likes to bounce ideas off a trampoline. He was once, in fact, a circus performer. "In some sense juggling and acrobatics are an extension of the mathematical work. When I'm working on a problem it's important for me to get up and walk around, and a one-armed handstand is my way of walking around."

"The eureka experience is common in the morning, after a night's sleep. It's well accepted by most mathematicians that an effective way of working on a problem is to think about it hard, put it away, and let the brain do whatever it does to sort ideas, throw out the bad ones, and make unconscious connections." And sometimes Graham's brain best does whatever it does upside down.

"I was working on a combinatorial problem having to do with Ramsey theory, which is based on the fact that it's impossible for something to be completely chaotic; there's some order in even the most disordered situation." (Per Poincaré, we are not obliged to understand, though doing so might better equip us for life in the twenty-first century.)

"I was trying to capture that idea in a quantitative way, and I made an interesting connection in the middle of a back somersault with a triple twist. That complex a performance has to be reflex: you think the name of the trick and the body does the rest, so your mind is free. You can't always leave reality as freely as you might like. My wife [mathematician Fan Chung] was thinking seriously about a problem one day and ran her Honda into the back of a truck."

At the seventy-fifth-anniversary meeting of the Mathematical Association of America four years ago, Graham and fellow mathematician-jugglers Joe Buhler of Reed College, who is also a rock pianist, Brad Jackson of the University of California at Santa Cruz, and Peter Frankl, now living and working in Japan, put on a mathematical circus. (Buhler and Graham have even developed a language like musical notation for writing down juggling patterns.) Then the foursome presented papers discussing the math behind magic, music, juggling, and bouncing. Graham expounded on the one-armed handstand. "The fact that you do it on movable pedestals makes it easier. If you balance a broom on your palm, it's easier if you can move your hand around; if your hand remains stationary, it's much harder to balance. From the point of view of physics, if you want to keep something in balance, the center of gravity and the support point must be lined up. If you're on parallel bars or the ground, the point of support is fixed, so that when the center of gravity drifts, you have to exert more force in order to balance." Doing a handstand on a cane or something wobbly looks harder, Graham says, but the physics of the thing is much easier — you're the broom in the moving palm.

"And there are a lot of philosophical linkages between math and computer science and juggling. One is the search for pattern and structure. Another involves human error: Jugglers say the trouble with juggling is that the balls go where you throw them. Computer scientists say the problem with computers is that they do what you tell them. In both cases, any problems are our fault."

Graham and Diaconis are writing a book about mathematics and magic tricks. "Every chapter will begin with a good trick; then, in order to understand the trick, you'll have to learn something about math," says Graham.

Diaconis specializes in probability theory. "I'm the guy who figured out it takes seven shuffles before cards are really mixed up," he says. His form of relaxation is to invent magic tricks and perform them, something he's been doing since he was 5. Diaconis ran away from home at 14 to become a magician's assistant and toured until he was 24, when he started college.

"Martin Gardner brought me to math. When I was a kid in New York, he and magicians like Vernon hung around at a cafeteria on Forty-second Street. I used to invent tricks, and Martin put one of my tricks into Scientific American. It was a problem of how to make an unfair coin-flip fair. Suppose you and a friend want to flip for who will pay a restaurant check. Your friend takes out a coin that's warped. Or let's say he wants to flip something oddly shaped, like a thumbtack. He says that when it lands with the point touching the floor, you'll call that heads; if it lands with the point not touching the floor, you'll call that tails. You don't know the odds, you don't know the bias of the coin or tack, and you want to find a way to flip fairly. The thing I thought of was to flip twice. If it comes up heads-heads or tails-tails, you do it again. If it comes up heads-tails, you call that a generalized head. If it comes up tails-heads, you call that a generalized tail. If the coin or tack is skewed or unfair, no matter what its propensities, the chances of its coming up heads-tails are the same as the chances of its coming up tails-heads. The double flip gives you a mechanism for taking an unfair coin with an unknown bias and making it fair. Much later, by the way, I found out that John von Neumann had figured out the same thing decades before."

Two years ago Diaconis taught a freshman seminar on mathematics and magic. "Seventy students wanted to take the class," he says, "but I took only 12. Half the kids had a math background and half had a science background. After the class, two went off to do street performing on their own."

For Diaconis, magic isn't really an escape from the rigors of mathematical thought. "Throughout my career, math and magic have interplayed," he says. "Math is all-consuming. It's not a job — it's what I do and who I am. When I need a break to shake my head out, I cook Greek food. You can't cook and solve equations at the same time — although I believe the old subconscious is working all the time, and I let it simmer along with my pastitsio. In fact, I trust my subconscious more and more. That back burner is an important part of creative thought."

Judith Stone

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