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Е.В. Дмитриева, Н.С. Сахарова

ENGLISH FOR STUDENTS OF MATHEMATICS AND INFORMATION TECHNOLOGY

Учебное пособие

Рекомендовано ученым советом федерального государственного бюджетного образовательного учреждения высшего образования «Оренбургский государственный университет» для обучающихся по образовательным программам высшего образования по направлениям подготовки 02.03.01 Математика и компьютерные науки, 09.03.01 Информатика и вычислительная техника, 01.03.02 Прикладная математика и информатика, 10.05.01 Компьютерная безопасность, 02.03.02 Фундаментальная информатика и информационные технологии

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Учебное пособие состоит из 10 разделов, в которых представлены аутентичные тексты в сфере IT технологий и математики на английском языке, грамматический и лексический справочный материал, направленный на развитие аналитических, переводческих и коммуникативных умений студентов в области высоких технологий.

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Введение

Данное учебное пособие составлено в рамках ООП по дисциплине «Иностранный язык» и предназначено для обучения студентов чтению, пониманию, прямому и обратному переводу оригинальных текстов в сфере математики и информационных технологий на английском языке. Текстовый материал пособия направлен на развитие аналитических, переводческих и коммуникативных умений студентов в IT-технологий.

Целью пособия является развитие профессионально-ориентированной иноязычной компетентности студентов 1 и 2 курсов, по направлениям подготовки 02.03.01 Математика и компьютерные науки, 09.03.01 Информатика и вычислительная техника, 01.03.01 Математика, 01.03.02 Прикладная математика и информатика (бакалавриат). Пособие состоит из десяти разделов, каждый из которых включает аутентичные тексты на английском языке, послетекстовые задания и список слов к разделу, разделы 4-6 предназначены для контроля сформировавшихся компетенций по результатам освоения дисциплины во 2 и 3 семестрах.

Практическая ценность пособия заключается в наличии аутентичного материала, системы разнообразных упражнений на развитие аналитических, и коммуникативных умений, а также навыков прямого и обратного перевода текстов по специальности с использованием профессиональной терминологии как в аудитории под контролем преподавателя, так и самостоятельно. Материалы пособия направлены не только на расширение лингвистических, но и профессионально-ориентированных знаний средствами английского языка в процессе выполнения коммуникативных заданий.

1 Unit 1 University Training

1.1 The Faculty of Mathematics and Information Technologies

1.1.1 Read and translate text A:

The faculty of mathematics was set up at the Orenburg State University in 2005. In 2015 it was reorganized into the faculty of the Faculty of Mathematics and Information Technologies. It offers a four or five-years training on the following programs: "Applied mathematics and informatics", "Mathematics and Computer sciences", "Computer security", "Computer science and computer engineering", "Information security", "Mathematics", "Fundamental informatics" and others.

The training at the faculty is aimed at providing students with fundamental scientific knowledge as well as practical skills, research abilities and critical-thinking. The academic curricula imply studying fundamental mathematics and advanced information technologies during the first two years. Students are supposed to master such humanitarian subjects like history, philosophy, psychology, foreign language (English). They help students to form their world outlook and improve their general knowledge and culture.

Senior students major in various specialized courses and study several programming languages, system analysis, informatics, and economics. A considerable part of academic time of the whole course of instruction is spent on various computer systems and fundamentals of mathematics. Students can learn, apply and examine different programming languages. They are also concerned with controlling and managing the software development process. In addition to humanitarian and special subjects they also study computer graphics, network design or the Internet. Students have up-to-date laboratories, computer classrooms with Internet access at their disposal.

Students can get optional courses such as “Translator in the sphere of professional communication” and “Web-designer”.

Students attend lectures, practical classes, tutorials and do laboratory works. At the end of each term students take examinations, tests and write course papers. The highly-qualified teachers and lectures are in the university staff.

The graduates of the mathematics and information technologies faculty are in great demand in the Orenburg region economy. Profound knowledge and skills let them take high-paid positions in various branches of industry. They can work as a computer software designer, network manager, Internet programmer, software engineer, system analyst, database developer, information systems manager.

The university graduates can take Bachelor's, Master's degree and attend post-graduate course.

1.1.2 Memorize vocabulary to the text:

purpose – цель;

academic curriculum – учебная программа;

world outlook – мировоззрение;

senior students – студенты старших курсов;

wide range – широкий выбор;

considerable part – значительная часть;

access – доступ;

post-graduate course – аспирантура;

research work – научно-исследовательская работа;

issue – вопрос, проблема;

software – программное обеспечение;

assessment – оценка работы;

on completion – по окончании;

up-to-date – современный;

to achieve – достичь;

to improve – усовершенствовать;

to master (syn.to acquire) – овладеть, приобрести;

to provide – обеспечить;

to be in great demand – пользоваться большим спросом;

to deal with – иметь дело с ...;

to be inclined for – иметь склонность к ...;

to vary – различаться, варьировать.

1.1.3 Translate the following groups of words. Mind the difference in meaning and pronunciation, consult the dictionary if necessary:

mathematics (maths) – mathematical – mathematician;

to apply – application – applicable;

to specialize – special – speciality – specialized – specialist;

to inform - information – informative – informatics;

to practice – practice – practical – unpractical – practically;

technology – technological – technique – technician – high-tech;

economy – economic – economics – economical – economically;

to compute – computer – computing – computation;

to add – addition – additional – additionally;

to act – action – active – activity – to activate;

to develop – development – underdeveloped – developer;

to analyze – analysis – analyst – analytical.

1.1.4 Find in the Text A English equivalents for the following Russian phrases:

был реорганизован, был основан, факультет математики и информационных технологий, направлены на, основы научных знаний, критическое мышление, исследовательские навыки, учебные программы, овладевать (осваивать), формировать мировоззрение, общий уровень культуры и знаний, управлять процессом разработки ПО, в дополнение к, современные лаборатории, в распоряжении, факультативные курсы, консультации, быть востребованным, заниматься в аспирантуре, отрасли промышленности, высокооплачиваемая работа (должность).

1.2 My Speciality (Informatics)

1.2.1 Read and translate text B:

Computer Literacy

Informed citizens of our information-dependent society should be computer-literate, which means that they are able to use computers as everyday problem-solving devices and aware of the potential of computers to influence the quality of life.

There was a time when only privileged people had an opportunity to learn the basics, called the three R's: reading, writing, and arithmetics. Now, as we are quickly becoming an information-becoming society, it is time to restate this right as the right to learn reading, writing and *computing.* There is little doubt that computers and their many applications are among the most significant technical achievements of the century. They bring with them both economic and social changes. "Computing" is a concept that embraces not only the old third R, arithmetics, but also a new idea – computer literacy.

In an information society a person who is computer-literate need not be an expert on the design of computers. He needn't even know much about how to prepare *programs* which are the instructions that direct the operations of computers. All of us are already on the way to becoming computer-literate. Just think of your everyday life. If you receive a subscription magazine in the post-office, it is probably addressed to you by a computer. If you buy something with a bank credit card or pay a bill by check, computers help you process the information. When you check out at the counter of your store, a computer assists the checkout clerk and the store manager. When you visit your doctor, your schedules and bills and special services, such as laboratory tests, are prepared by computer. Many actions that you have taken or observed have much in common. Each relates to some aspect of a data processing system.

1.2.2 Find in the Text A English equivalents for the following Russian phrases:

следует; компьютерная грамотность; устройство, обеспечивающее решение задач; информационное общество; пересмотреть, переосмыслить; вычисление, работа на компьютере; журнал по подписке; обрабатывать; система обработки данных.

1.2.3 Answer the questions:

1 What does the computer literacy mean? 2 What are the three R's? 3 What are the most significant technical achievements of the century? 4 What is "Computing"? 5 What is program? 6 Where can the computers be used?

1.2.4 Fill in the gaps:

I'm a _________ at the _______. It was _________ at the Orenburg State University in 2005. In 2015 it was reorganized into the faculty of ________. It trains students on the following programs: ____________.

My specialty is __________. The training is aimed at providing students with _________as well as __________. The academic curricula imply studying __________during the first two years. Students are supposed to master such humanitarian subjects like ________. They help students to form their world outlook and improve their general knowledge and culture.

Senior students major in various specialized courses ________. A considerable part of academic time of the whole course of instruction is spent on _________. Students can learn, apply and examine different programming languages: ________. They are also concerned with controlling and managing the software development process. In addition to humanitarian and special subjects they also study __________. Students have ______________at their disposal.

Students can get optional courses such as ____________.

Students attend ________ and do _________. At the end of each term students take ________, ________ and write _______. The highly-qualified teachers and lectures are in the university staff .

The graduates of the mathematics and information technologies faculty are _________ in the Orenburg region economy. Profound knowledge and skills let them take high-paid positions in various branches of industry. They can work as _________________.

The university graduates can take _________ degree and attend _________.

1.2.5 Speak on the topic "My Speciality".

2 Unit 2 Mathematics

2.1 Mathematics

2.1.1 Read and translate text A:

Mathematics (from Greek μάθημα *máthēma*, “knowledge, study, learning”) is the study of topics such as quantity (numbers),structure, space, and change. There is a range of views among mathematicians and philosophers as to the exact scope and definition of mathematics.

Mathematicians seek out patterns and use them to formulate new conjectures. Mathematicians resolve the truth or falsity of conjectures by mathematical proof. When mathematical structures are good models of real phenomena, then mathematical reasoning can provide insight or predictions about nature. Through the use of abstraction and logic, mathematics developed from counting, calculation, measurement, and the systematic study of the shapes and motions of physical objects. Practical mathematics has been a human activity for as far back as written records exist. The research required to solve mathematical problems can take years or even centuries of sustained inquiry.

Rigorous arguments first appeared in Greek mathematics, most notably in Euclid's *Elements* (Fig. 1). Since the pioneering work of Giuseppe Peano (1858-1932), David Hilbert (1862-1943), and others on axiomatic systems in the late 19th century, it has become customary to view mathematical research as establishing truth by rigorous deduction from appropriately chosen axioms and definitions. Mathematics developed at a relatively slow pace until the Renaissance, when mathematical innovations interacting with new scientific discoveries led to a rapid increase in the rate of mathematical discovery that has continued to the present day.

Figure 1 – Euclid (holding calipers), Greek mathematician, 3rd century BC, as imagined by Raphael in this detail from The School of Athens

Galileo Galilei (1564-1642) said, "The universe cannot be read until we have learned the language and become familiar with the characters in which it is written. It is written in mathematical language, and the letters are triangles, circles and other geometrical figures, without which means it is humanly impossible to comprehend a single word. Without these, one is wandering about in a dark labyrinth." Carl Friedrich Gauss (1777-1855) referred to mathematics as "the Queen of the Sciences". Benjamin Peirce (1809-1880) called mathematics "the science that draws necessary conclusions". David Hilbert said of mathematics: "We are not speaking here of arbitrariness in any sense. Mathematics is not like a game whose tasks are determined by arbitrarily stipulated rules. Rather, it is a conceptual system possessing internal necessity that can only be so and by no means otherwise." Albert Einstein (1879-1955) stated that "as far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality."

Mathematics is essential in many fields, including natural science, engineering, medicine, finance and the social sciences. Applied mathematics has led to entirely new mathematical disciplines, such as statistics and game theory. Mathematicians also engage in pure mathematics, or mathematics for its own sake, without having any application in mind. There is no clear line separating pure and applied mathematics, and practical applications for what began as pure mathematics are often discovered.

Mathematics is the study of quantity, structure, space, and change. Mathematicians seek out patterns, formulate new conjectures, and establish truth by rigorous deduction from appropriately chosen axioms and definitions.

Mathematics has been vital to the development of civilization; from ancient to modern times it has been fundamental to advances in science, engineering, and philosophy.

Through the use of abstraction and logical reasoning, mathematics evolved from counting, calculation, measurement, and the systematic study of the shapes and motions of physical objects. Practical mathematics has been a human activity for as far back as written records exist.

Rigorous arguments first appeared in Greek mathematics, most notably in Euclid's Elements. Mathematics continued to develop, for example in China in 300 BCE, in India in 100 CE, and in Arabia in 800 CE, until the Renaissance, when mathematical innovations interacting with new scientific discoveries led to a rapid increase in the rate of mathematical discovery. Later some of this mathematics was translated into Latin and became the mathematics of Western Europe. Over a period of several hundred years, it became the mathematics of the world. Now there is one predominant international mathematics.

By the 20th century the edge of that unknown had receded to where only a few could see. One was David Hilbert, a leading mathematician of the turn of the century. In 1900 he addressed the International Congress of Mathematicians in Paris, and described 23 important mathematical problems.

Mathematics is used throughout the world as an essential tool in many fields, including natural science, engineering, medicine, and the social sciences. Applied mathematics, the branch of mathematics concerned with application of mathematical knowledge to other fields, inspires and makes use of new mathematical discoveries and sometimes leads to the development of entirely new mathematical disciplines, such as statistics and game theory. Mathematicians also engage in pure mathematics without having any application in mind.

Mathematics continues to grow at a phenomenal rate. There is no end in sight, and the application of mathematics to science becomes greater all the time.

2.1.2 Find the meaning of the underlined words in the text A and memorize them.

2.1.3 Find the sentences with the given words in the text A:

conjecture – гипотеза;

to establish truth – устанавливать истину;

rigorous deduction – точный вывод;

human creations – человеческое изобретение;

to recede – отступать, удаляться;

vital – крайне важный, существенный;

advance – (зд.) продвижение, прогресс;

quantity – количество;

space – пространство;

to seek out pattern (sought, sought) – выводить формулу;

logical reasoning – логическое доказательство;

to evolve – развивать(ся);

motion – движение;

as far back as – уже, ещё;

written records – письменные записи;

rigorous arguments – строгие доказательства;

scientific discoveries – научные открытия;

rapid increase in the rate – стремительный рост темпа;

edge – край, граница;

turn of the century – рубеж веков;

essential tool – необходимый инструмент;

to inspire – вдохновлять;

to engage in – заниматься ч-л.;

applied / pure mathematics – прикладная / чистая математика.

2.1.4 Give the main ideas of the subject and history of mathematics

2.1.5 Give Russian equivalents to the major fields of mathematics. Describe their main subject of study in English:

Logic, Set theory, Category theory, Algebra (elementary – linear – abstract), Number theory, Analysis / Calculus, Geometry, Topology, Dynamical systems, Combinatorics, Game theory, Information theory, Numerical analysis, Optimization, Computation, Probability, Statistics, Trigonometry, Differential Equations.

2.2.1 Read and translate text B:

History of mathematics

The history of mathematics can be seen as an ever-increasing series of abstractions. The first abstraction, which is shared by many animals, was probably that of numbers: the realization that a collection of two apples and a collection of two oranges have something in common, namely quantity of their members.

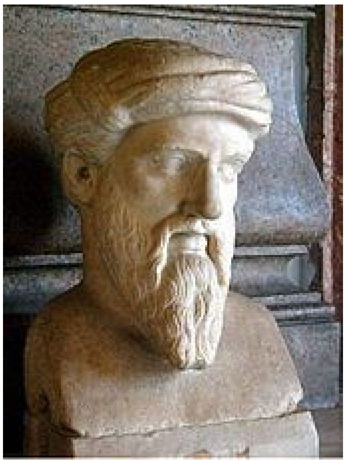


Figure 2 – Greek mathematician Pythagoras (c. 570 – c. 495 BC), commonly credited with discovering the Pythagorean theorem

As evidenced by tallies found on bone, in addition to recognizing how to count physical objects, prehistoric peoples may have also recognized how to count abstract quantities, like time – days, seasons, years (Fig. 3).

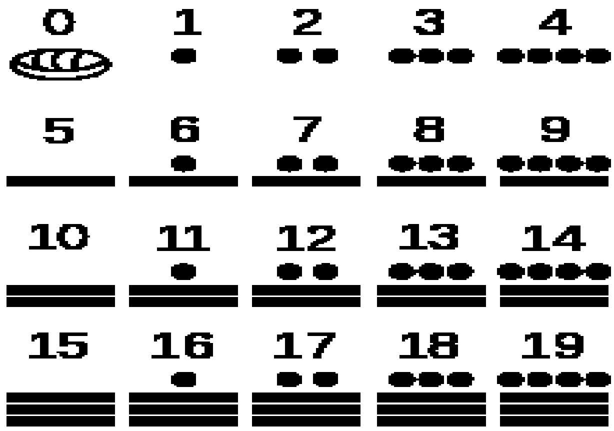


Figure 3 – Mayan numerals

Evidence for more complex mathematics does not appear until around 3000 BC, when the Babylonians and Egyptians began using arithmetic, algebra and geometry for taxation and other financial calculations, for building and construction, and for astronomy. The earliest uses of mathematics were in trading, land measurement, painting and weaving patterns and the recording of time.

In Babylonian mathematics elementary arithmetic (addition, subtraction, multiplication and division) first appears in the archaeological record. Numeracy pre-dated writing and numeral systems have been many and diverse, with the first known written numerals created by Egyptians in Middle Kingdom texts such as the Rhind Mathematical Papyrus.

Between 600 and 300 BC the Ancient Greeks began a systematic study of mathematics in its own right with Greek mathematics (Fig. 2).

During the Golden Age of Islam, especially during the 9th and 10th centuries, mathematics saw many important innovations building on Greek mathematics: most of them include the contributions from Persian mathematicians such as Al-Khwarismi, Omar Khayyam and Sharaf al-Dīn al-Ṭūsī figure 4.

Figure 4 – Persian mathematician Al-Khwarizmi - the inventor of the Algebra

Mathematics has since been greatly extended, and there has been a fruitful interaction between mathematics and science, to the benefit of both. Mathematical discoveries continue to be made today. According to Mikhail B. Sevryuk, in the January 2006 issue of the *Bulletin of the American Mathematical Society*, "The number of papers and books included in the *Mathematical Reviews* database since 1940 (the first year of operation of MR) is now more than 1.9 million, and more than 75 thousand items are added to the database each year. The overwhelming majority of works in this ocean contain new mathematical theorems and their proofs."

Etymology

The word *mathematics* comes from the Greek μάθημα (*máthēma*), which, in the ancient Greek language, means "that which is learnt","what one gets to know", hence also "study" and "science", and in modern Greek just "lesson". The word *máthēma* is derived from μανθάνω (*manthano*), while the modern Greek equivalent is μαθαίνω (*mathaino*), both of which mean "to learn". In Greece, the word for "mathematics" came to have the narrower and more technical meaning "mathematical study" even in Classical times. Its adjective isμαθηματικός (*mathēmatikós*), meaning "related to learning" or "studious", which likewise further came to mean "mathematical". In particular, μαθηματικὴτέχνη (*mathēmatikḗ tékhnē*), Latin: *ars mathematica*, meant "the mathematical art".

In Latin, and in English until around 1700, the term *mathematics* more commonly meant "astrology" (or sometimes "astronomy") rather than "mathematics"; the meaning gradually changed to its present one from about 1500 to 1800. This has resulted in several mistranslations: a particularly notorious one isSaint Augustine's warning that Christians should beware of *mathematici* meaning astrologers, which is sometimes mistranslated as a condemnation of mathematicians.

The apparent plural form in English, like the French plural form *les mathématiques* (and the less commonly used singular derivative *la mathématique*), goes back to the Latin neuter plural *mathematica* (Cicero), based on the Greek plural τα μαθηματικά (*ta mathēmatiká*), used by Aristotle (384-322 BC), and meaning roughly "all things mathematical"; although it is plausible that English borrowed only the adjective *mathematic(al)* and formed the noun *mathematics* anew, after the pattern of physics and metaphysics, which were inherited from the Greek. In English, the noun *mathematics* takes singular verb forms. It is often shortened to *maths* or, in English-speaking North America, *math*.

Figure 5 – Leonardo Fibonacci, the Italian mathematician who established the Hindu–Arabic numeral system to the Western World

Aristotle defined mathematics as "the science of quantity", and this definition prevailed until the 18th century. Starting in the 19th century, when the study of mathematics increased in rigor and began to address abstract topics such as group theory and projective geometry, which have no clear-cut relation to quantity and measurement, mathematicians and philosophers began to propose a variety of new definitions. Some of these definitions emphasize the deductive character of much of mathematics, some emphasize its abstractness, some emphasize certain topics within mathematics (Fig. 5). Today, no consensus on the definition of mathematics prevails, even among professionals. There is not even consensus on whether mathematics is an art or a science. A great many professional mathematicians take no interest in a definition of mathematics, or consider it undefinable. Some just say, "Mathematics is what mathematicians do."

Three leading types of definition of mathematics are called logicist, intuitionist, and formalist, each reflecting a different philosophical school of thought. All have severe problems, none has widespread acceptance, and no reconciliation seems possible.

An early definition of mathematics in terms of logic was Benjamin Peirce's "the science that draws necessary conclusions" (1870). In the *Principia Mathematica*, Bertrand Russell and Alfred North Whitehead advanced the philosophical program known as logicism, and attempted to prove that all mathematical concepts, statements, and principles can be defined and proven entirely in terms of symbolic logic. A logicist definition of mathematics is Russell's "All Mathematics is Symbolic Logic" (1903).

Intuitionist definitions, developing from the philosophy of mathematician L.E.J. Brouwer, identify mathematics with certain mental phenomena. An example of an intuitionist definition is "Mathematics is the mental activity which consists in carrying out constructs one after the other." A peculiarity of intuitionism is that it rejects some mathematical ideas considered valid according to other definitions. In particular, while other philosophies of mathematics allow objects that can be proven to exist even though they cannot be constructed, intuitionism allows only mathematical objects that one can actually construct.

Formalist definitions identify mathematics with its symbols and the rules for operating on them. Haskell Curry defined mathematics simply as "the science of formal systems". A formal system is a set of symbols, or *tokens*, and some *rules* telling how the tokens may be combined into *formulas*. In formal systems, the word *axiom* has a special meaning, different from the ordinary meaning of "a self-evident truth". In formal systems, an axiom is a combination of tokens that is included in a given formal system without needing to be derived using the rules of the system.

Mathematics as science

Gauss referred to mathematics as "the Queen of the Sciences". In the original Latin *Regina Scientiarum*, as well as in German *Königin der Wissenschaften*, the word corresponding to *science* means a "field of knowledge", and this was the original meaning of "science" in English, also; mathematics is in this sense a field of knowledge. The specialization restricting the meaning of "science" to *natural science* follows the rise of Baconian science, which contrasted "natural science" to scholasticism, the Aristotelean method of inquiring from first principles. The role of empirical experimentation and observation is negligible in mathematics, compared to natural sciences such as biology, chemistry, or physics. Albert Einstein stated that "as far as the laws of mathematics refer to reality, they are not certain; and as far as they are certain, they do not refer to reality." More recently, Marcus du Sautoy has called mathematics "the Queen of Science ... the main driving force behind scientific discovery".

Figure 6 – Carl Friedrich Gauss, known as the prince of mathematicians

Many philosophers believe that mathematics is not experimentally falsifiable, and thus not a science according to the definition of Karl Popper. However, in the 1930s Gödel's incompleteness theorems convinced many mathematicians that mathematics cannot be reduced to logic alone, and Karl Popper concluded that "most mathematical theories are, like those of physics and biology, hypothetico-deductive: pure mathematics therefore turns out to be much closer to the natural sciences whose hypotheses are conjectures, than it seemed even recently." Other thinkers, notably Imre Lakatos, have applied a version of falsificationism to mathematics itself.

An alternative view is that certain scientific fields (such as theoretical physics) are mathematics with axioms that are intended to correspond to reality. The theoretical physicist J.M. Ziman proposed that science is *public knowledge*, and thus includes mathematics. Mathematics shares much in common with many fields in the physical sciences, notably the exploration of the logical consequences of assumptions. Intuition and experimentation also play a role in the formulation of conjectures in both mathematics and the (other) sciences. Experimental mathematics continues to grow in importance within mathematics, and computation and simulation are playing an increasing role in both the sciences and mathematics.

The opinions of mathematicians on this matter are varied. Many mathematicians feel that to call their area a science is to downplay the importance of its aesthetic side, and its history in the traditional seven liberal arts; others feel that to ignore its connection to the sciences is to turn a blind eye to the fact that the interface between mathematics and its applications in science and engineering has driven much development in mathematics. One way this difference of viewpoint plays out is in the philosophical debate as to whether mathematics is *created* as in art or *discovered* as in science. It is common to see universities divided into sections that include a division of *Science and Mathematics*, indicating that the fields are seen as being allied but that they do not coincide. In practice, mathematicians are typically grouped with scientists at the gross level but separated at finer levels. This is one of many issues considered in the philosophy of mathematics.

Mathematics arises from many different kinds of problems. At first these were found in commerce, land measurement, architecture and later astronomy; today, all sciences suggest problems studied by mathematicians, and many problems arise within mathematics itself. For example, the physicist Richard Feynman invented the path integral formulation of quantum mechanics using a combination of mathematical reasoning and physical insight, and today's string theory, a still-developing scientific theory which attempts to unify the four fundamental forces of nature, continues to inspire new mathematics （Fig. 7）.

Some mathematics is relevant only in the area that inspired it, and is applied to solve further problems in that area. But often mathematics inspired by one area proves useful in many areas, and joins the general stock of mathematical concepts.

Figure 7 – Isaac Newton (left) and Gottfried Wilhelm Leibniz (right), developers of infinitesimal calculus

A distinction is often made between pure mathematics and applied mathematics. However pure mathematics topics often turn out to have applications, e.g. number theory in cryptography. This remarkable fact, that even the "purest" mathematics often turns out to have practical applications, is what Eugene Wigner has called "the unreasonable effectiveness of mathematics". As in most areas of study, the explosion of knowledge in the scientific age has led to specialization: there are now hundreds of specialized areas in mathematics and the latest Mathematics Subject Classification runs to 46 pages. Several areas of applied mathematics have merged with related traditions outside of mathematics and become disciplines in their own right, including statistics, operations research, and computer science.

For those who are mathematically inclined, there is often a definite aesthetic aspect to much of mathematics. Many mathematicians talk about the *elegance* of mathematics, its intrinsic aesthetics and inner beauty. Simplicity and generality are valued. There is beauty in a simple and elegant proof, such as Euclid's proof that there are infinitely many prime numbers, and in an elegant numerical method that speeds calculation, such as the fast Fourier transform. G.H. Hardy in *A Mathematician's Apology* expressed the belief that these aesthetic considerations are, in themselves, sufficient to justify the study of pure mathematics. He identified criteria such as significance, unexpectedness, inevitability, and economy as factors that contribute to a mathematical aesthetic. Mathematicians often strive to find proofs that are particularly elegant, proofs from "The Book" of God according to Paul Erdős. The popularity of recreational mathematics is another sign of the pleasure many find in solving mathematical questions.

Mathematical notation

Most of the mathematical notation in use today was not invented until the 16th century. Before that, mathematics was written out in words, limiting mathematical discovery. Euler (1707-1783) (Fig. 8) was responsible for many of the notations in use today. Modern notation makes mathematics much easier for the professional, but beginners often find it daunting. It is compressed: a few symbols contain a great deal of information. Like musical notation, modern mathematical notation has a strict syntax and encodes information that would be difficult to write in any other way.

Mathematical language can be difficult to understand for beginners. Common words such as *or* and *only* have more precise meanings than in everyday speech. Moreover, words such as *open* and *field* have specialized mathematical meanings. Technical terms such as *homeomorphism* and *integrable* have precise meanings in mathematics. Additionally, shorthand phrases such as *iff* for "if and only if" belong to mathematical jargon. There is a reason for special notation and technical vocabulary: mathematics requires more precision than everyday speech. Mathematicians refer to this precision of language and logic as "rigor".

Figure 8 – Leonhard Euler, who created and popularized much of the mathematical notation used today.

Mathematical proof is fundamentally a matter of rigor. Mathematicians want their theorems to follow from axioms by means of systematic reasoning. This is to avoid mistaken "theorems", based on fallible intuitions, of which many instances have occurred in the history of the subject. The level of rigor expected in mathematics has varied over time: the Greeks expected detailed arguments, but at the time of Isaac Newton the methods employed were less rigorous. Problems inherent in the definitions used by Newton would lead to a resurgence of careful analysis and formal proof in the 19th century. Misunderstanding the rigor is a cause for some of the common misconceptions of mathematics. Today, mathematicians continue to argue among themselves about computer-assisted proofs. Since large computations are hard to verify, such proofs may not be sufficiently rigorous.

Axioms in traditional thought were "self-evident truths", but that conception is problematic. At a formal level, an axiom is just a string of symbols, which has an intrinsic meaning only in the context of all derivable formulas of an axiomatic system. It was the goal of Hilbert's program to put all of mathematics on a firm axiomatic basis, but according to Gödel's incompleteness theorem every (sufficiently powerful) axiomatic system has undecidable formulas; and so a final axiomatization of mathematics is impossible. Nonetheless mathematics is often imagined to be (as far as its formal content) nothing but set theory in some axiomatization, in the sense that every mathematical statement or proof could be cast into formulas within set theory.

2.2.2 Write out mathematical terms from the text B, translate and learn them.

2.2.3 Write the main stages of maths development in chronological order.

2.2.4 Answer the following questions:

1 What can the history of maths be seen as? 2 What kind of mathematics did prehistoric people use? 3 When did more complex mathematics appear? 4 What is the etymology of the word mathematics? 5 Give three leading types of definition of mathematics as a science. 6 Give some examples of definition of mathematics by different authors. 7 Prove that mathematics is a science. 8 What famous scientists are mentioned in the text?

2.2.5 Speak about a famous scientist.

3 Unit 3 Fields of Mathematics

3.1 Foundations and Philosophy

3.1.1 Read and translate text A:

Mathematics can, broadly speaking, be subdivided into the study of quantity, structure, space, and change (i.e. arithmetic, algebra, geometry, and analysis). In addition to these main concerns, there are also subdivisions dedicated to exploring links from the heart of mathematics to other fields: to logic, to set theory (foundations), to the empirical mathematics of the various sciences (applied mathematics), and more recently to the rigorous study of uncertainty. While some areas might seem unrelated, the Langlands program has found connections between areas previously thought unconnected, such as Galois groups, Riemann surfaces and number theory (Fig. 9).

In order to clarify the foundations of mathematics, the fields of mathematical logic and set theory were developed. Mathematical logic includes the mathematical study of logic and the applications of formal logic to other areas of mathematics; set theory is the branch of mathematics that studies sets or collections of objects. Category theory, which deals in an abstract way with mathematical structures and relationships between them, is still in development. The phrase "crisis of foundations" describes the search for a rigorous foundation for mathematics that took place from approximately 1900 to 1930. Some disagreement about the foundations of mathematics continues to the present day. The crisis of foundations was stimulated by a number of controversies at the time, including the controversy over Cantor's set theory and the Brouwer–Hilbert controversy.

Fields of mathematics

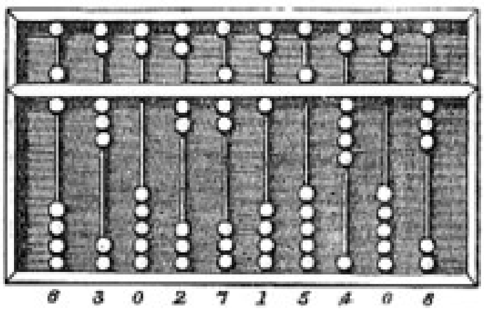
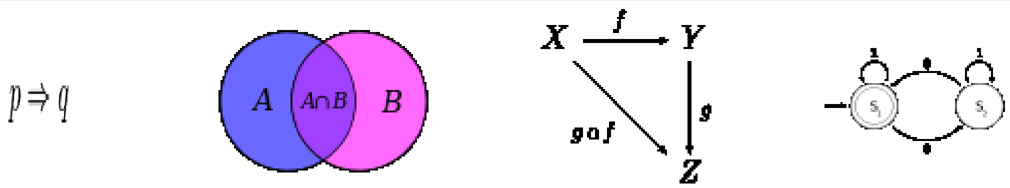


Figure 9 – An abacus, a simple calculating tool used since ancient times

Mathematical logic is concerned with setting mathematics within a rigorous axiomatic framework, and studying the implications of such a framework. As such, it is home to Gödel's incompleteness theorems which (informally) imply that any effective formal system that contains basic arithmetic, if *sound* (meaning that all theorems that can be proven are true), is necessarily *incomplete* (meaning that there are true theorems which cannot be proved *in that system*). Whatever finite collection of number-theoretical axioms is taken as a foundation, Gödel showed how to construct a formal statement that is a true number-theoretical fact, but which does not follow from those axioms. Therefore, no formal system is a complete axiomatization of full number theory. Modern logic is divided into recursion theory, model theory, and proof theory, and is closely linked to theoretical computer science, as well as to category theory.

Theoretical computer science includes computability theory, computational complexity theory, and information theory (Fig. 10). Computability theory examines the limitations of various theoretical models of the computer, including the most well-known model – the Turing machine. Complexity theory is the study of tractability by computer; some problems, although theoretically solvable by computer, are so expensive in terms of time or space that solving them is likely to remain practically unfeasible, even with the rapid advancement of computer hardware. A famous problem is the "P = NP?" problem, one of the Millennium Prize Problems. Finally, information theory is concerned with the amount of data that can be stored on a given medium, and hence deals with concepts such as compression and entropy.



Mathematical logic | Set theory | Category theory | Theory of computation

Figure 10 – Fields of information theory

Pure mathematics Quantity

The study of quantity starts with numbers, first the familiar natural numbers and integers ("whole numbers") and arithmetical operations on them, which are characterized in arithmetic. The deeper properties of integers are studied in number theory, from which come such popular results as Fermat's Last Theorem. The twin prime conjecture and Goldbach's conjecture are two unsolved problems in number theory.

As the number system (Fig. 11) is further developed, the integers are recognized as a subset of the rational numbers ("fractions"). These, in turn, are contained within the real numbers, which are used to represent continuous quantities. Real numbers are generalized to complex numbers. These are the first steps of a hierarchy of numbers that goes on to include quaternions and octonions. Consideration of the natural numbers also leads to the transfinite numbers, which formalize the concept of "infinity". Another area of study is size, which leads to the cardinal numbers and then to another conception of infinity: the aleph numbers, which allow meaningful comparison of the size of infinitely large sets.

$1, 2, 3, \ldots$	$\ldots, -2, -1, 0, 1, 2 \ldots$	$-2, \frac{2}{3}, 1.21$	$-e, \sqrt{2}, 3, \pi$	$2, i, -2+3i, 2e^{i\frac{4\pi}{3}}$
Natural numbers	Integers	Rational numbers	Real numbers	Complex numbers

Figure 11 – Number system

Structure

Many mathematical objects, such as sets of numbers and functions, exhibit internal structure as a consequence of operations or relations that are defined on the set. Mathematics then studies properties of those sets that can be expressed in terms of that structure; for instance number theory studies properties of the set of integers that can be expressed in terms of arithmetic operations. Moreover, it frequently happens that different such structured sets (or structures) exhibit similar properties, which makes it possible, by a further step of abstraction, to state axioms for a class of structures, and then study at once the whole class of structures satisfying these axioms. Thus one can study groups, rings, fields and other abstract systems; together such studies (for structures defined by algebraic operations) constitute the domain of abstract algebra.

By its great generality, abstract algebra can often be applied to seemingly unrelated problems; for instance a number of ancient problems concerning compass and straightedge constructions were finally solved using Galois theory which involves field theory and group theory. Another example of an algebraic theory is linear algebra, which is the general study of vector spaces, whose elements called vectors have both quantity and direction, and can be used to model (relations between) points in space. This is one example of the phenomenon that the originally unrelated areas of geometry and algebra have very strong interactions in modern mathematics. Combinatorics studies ways of enumerating the number of objects that fit a given structure (Fig. 12).

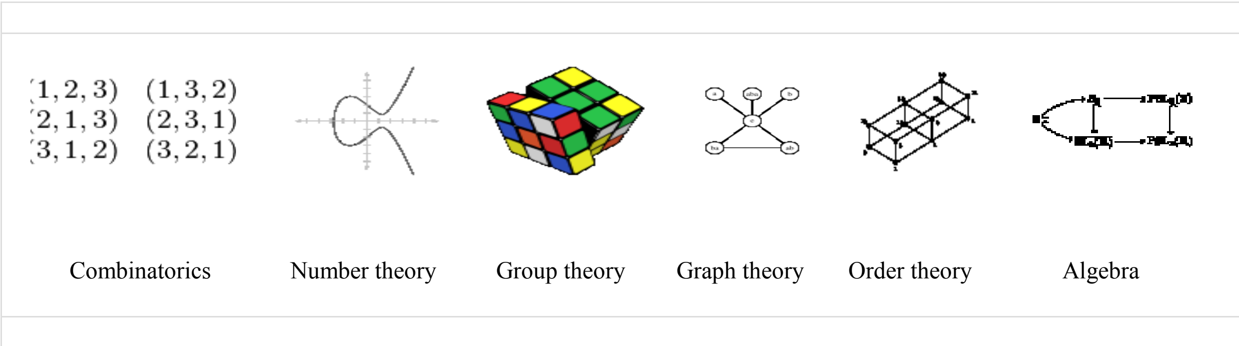
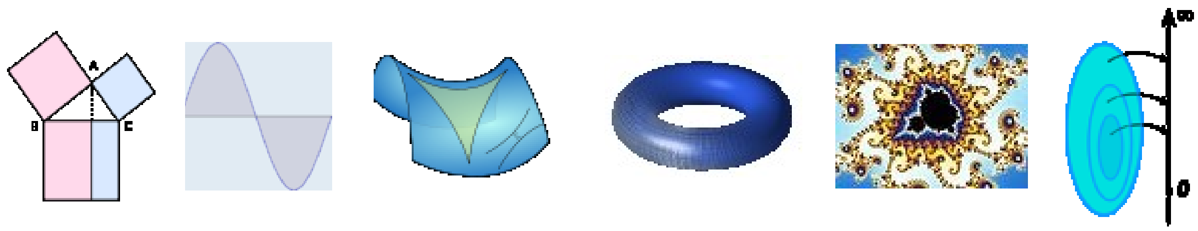


Figure 12 – Ways of enumerating the number of objects

Space

The study of space originates with geometry – in particular, Euclidean geometry. Trigonometry is the branch of mathematics that deals with relationships between the sides and the angles of triangles and with the trigonometric functions; it combines space and numbers, and encompasses the well-known Pythagorean theorem. The modern study of space generalizes these ideas to include higher-dimensional geometry, non-Euclidean geometries (which play a central role in general relativity) and topology. Quantity and space both play a role in analytic geometry, differential geometry, and algebraic geometry. Convex and discrete geometry were developed to solve problems in number theory and functional analysis but now are pursued with an eye on applications in optimization and computer science. Within differential geometry are the concepts of fiber bundles and calculus on manifolds, in particular, vector and tensor calculus. Within algebraic geometry is the description of geometric objects as solution sets of polynomial equations, combining the concepts of quantity and space, and also the study of topological groups, which combine structure and space (Fig. 13). Lie groups are used to study space, structure, and change. Topology in all its many ramifications may have been the greatest growth area in 20th-century mathematics; it includes point-set topology, set-theoretic topology, algebraic topology and differential topology. In particular, instances of modern-day topology are metrizability theory, axiomatic set theory, homotopy theory, and Morse theory. Topology also includes the now solved Poincaré conjecture, and the still unsolved areas of the Hodge conjecture. Other results in geometry and topology, including the four color theorem and Kepler conjecture, have been proved only with the help of computers.



Geometry | Trigonometry | Differential geometry | Topology | Fractal geometry | Measure theory

Figure 13 – Study of space with geometry

Change

Understanding and describing change is a common theme in the natural sciences, and calculus was developed as a powerful tool to investigate it (Fig. 14). Functions arise here, as a central concept describing a changing quantity. The rigorous study of real numbers and functions of a real variable is known as real analysis, with complex analysis the equivalent field for the complex numbers. Functional analysis focuses attention on (typically infinite-dimensional) spaces of functions. One of many applications of functional analysis is quantum mechanics. Many problems lead naturally to relationships between a quantity and its rate of change, and these are studied as differential equations. Many phenomena in nature can be described by dynamical systems; chaos theory makes precise the ways in which many of these systems exhibit unpredictable yet still deterministic behavior.

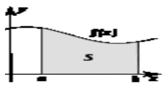
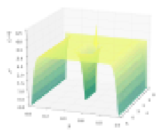
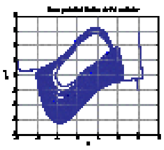
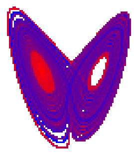
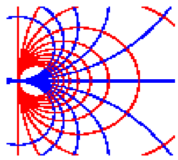
					
Calculus	Vector calculus	Differential equations	Dynamical systems	Chaos theory	Complex analysis

Figure 14 – Change description in the natural sciences

Applied mathematics

Applied mathematics concerns itself with mathematical methods that are typically used in science, engineering, business, and industry. Thus, "applied mathematics" is a mathematical science with specialized knowledge. The term *applied mathematics* also describes the professional specialty in which mathematicians work on practical problems; as a profession focused on practical problems, *applied mathematics* focuses on the "formulation, study, and use of mathematical models" in science, engineering, and other areas of mathematical practice.

In the past, practical applications have motivated the development of mathematical theories, which then became the subject of study in pure mathematics, where mathematics is developed primarily for its own sake. Thus, the activity of applied mathematics is vitally connected with research in pure mathematics.

Statistics and other decision sciences

Applied mathematics has significant overlap with the discipline of statistics, whose theory is formulated mathematically, especially with probability theory. Statisticians (working as part of a research project) "create data that makes sense" with random sampling and with randomized experiments; the design of a statistical sample or experiment specifies the analysis of the data (before the data be available). When reconsidering data from experiments and samples or when analyzing data from observational studies, statisticians "make sense of the data" using the art of modelling and the theory of inference – with model selection and estimation; the estimated models and consequential predictions should be tested on new data.

Statistical theory studies decision problems such as minimizing the risk (expected loss) of a statistical action, such as using a procedure in, for example, parameter estimation, hypothesis testing, and selecting the best. In these traditional areas of mathematical statistics, a statistical-decision problem is formulated by minimizing an objective function, like expected loss or cost, under specific constraints: For example, designing a survey often involves minimizing the cost of estimating a population mean with a given level of confidence. Because of its use of optimization, the mathematical theory of statistics shares concerns with other decision sciences, such as operations research, control theory, and mathematical economics.

Computational mathematics

Computational mathematics proposes and studies methods for solving mathematical problems that are typically too large for human numerical capacity. Numerical analysis studies methods for problems in analysis using functional analysis and approximation theory; numerical analysis includes the study of approximation and discretization broadly with special concern for rounding errors. Numerical analysis and, more broadly, scientific computing also study non-analytic topics of mathematical science, especially algorithmic matrix and graph theory. Other areas of computational mathematics include computer algebra and symbolic computation (Fig. 15).

3.1.2 Translate the following words and word combinations:

quantity; space; change; dedicated to exploring links; applied mathematics; rigorous foundation; set theory; axiomatic framework; incompleteness theorem; computability theory; complexity theory; recursion theory; twin prime conjecture; unsolved problems; consequence of operations; research in pure mathematics; overlap; expected loss of cost.

3.1.3 Answer the following questions:

1 What sciences does mathematics deal with? 2 What fields were developed to clarify the foundation of mathematics? 3 What does mathematical logic include? 4 What does category theory deal with? 5 What problem is one of the Millennium Prize Problems? 6 What are two unsolved problems in number theory? 7 What does combinatoric study? 8 What does the study of space originate with? 9 What has been proved only with the help of computers? 10 What is the activity of applied mathematics connected with? 11 What does the statistical theory study? 12 What does computational mathematics propose and study?

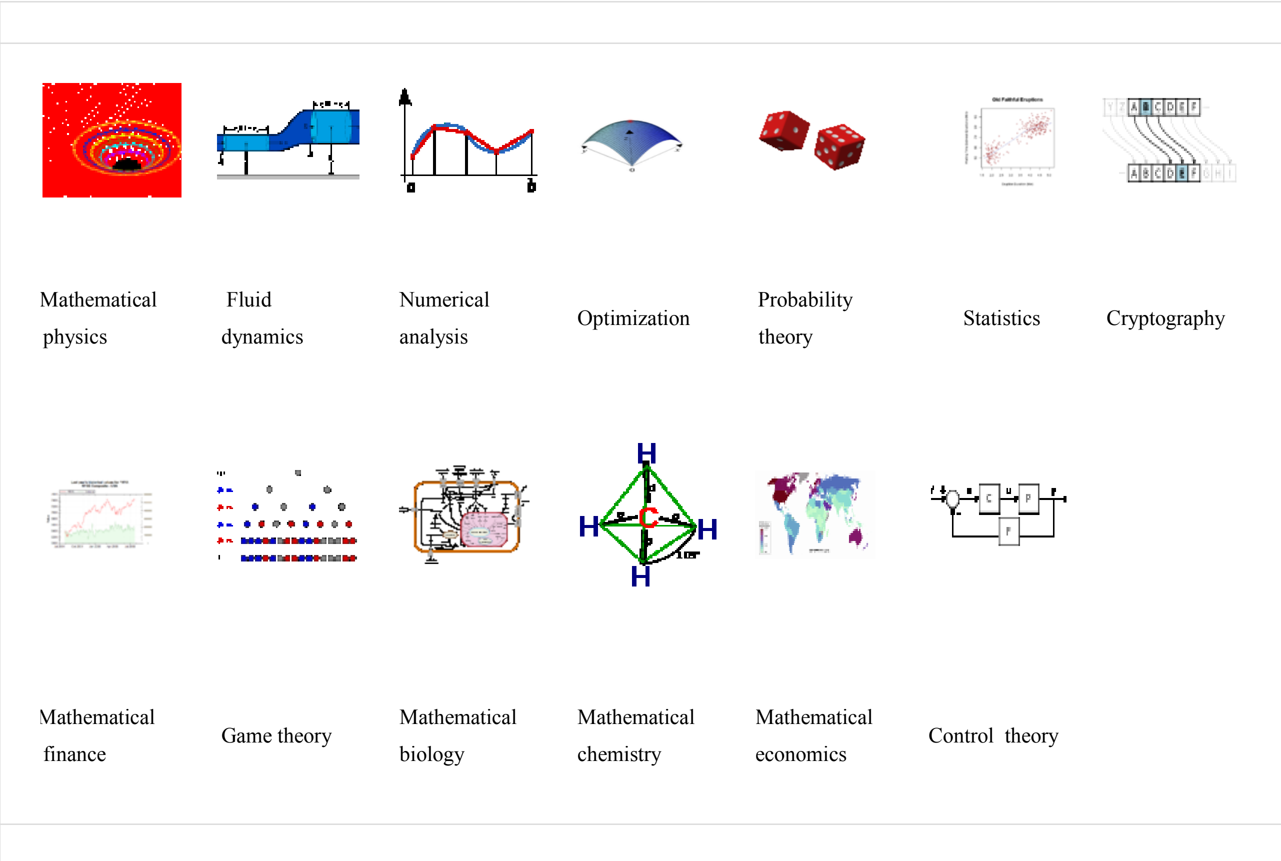


Figure 15 – Computational mathematics methods

3.1.4 Write out from the text A sentences in the Passive Voice, define the Tense and translate them.

3.1.5 Read and translate the text in written form. Find what other mathematical awards exist and what Russian mathematicians received such awards.

Mathematical awards

Arguably the most prestigious award in mathematics is the Fields Medal, established in 1936 and awarded every four years (except around World War II) to as many as four individuals. The Fields Medal is often considered a mathematical equivalent to the Nobel Prize.

The Wolf Prize in Mathematics, instituted in 1978, recognizes lifetime achievement, and another major international award, the Abel Prize, was introduced in 2003. The Chern Medal was introduced in 2010 to recognize lifetime achievement. These accolades are awarded in recognition of a particular body of work, which may be innovational, or provide a solution to an outstanding problem in an established field.

A famous list of 23 open problems, called "Hilbert's problems", was compiled in 1900 by German mathematician David Hilbert. This list achieved great celebrity among mathematicians, and at least nine of the problems have now been solved. A new list of seven important problems, titled the "Millennium Prize Problems", was published in 2000. A solution to each of these problems carries a $1 million reward, and only one (the Riemann hypothesis) is duplicated in Hilbert's problems.

3.2 Algebra

3.2.1 Read and translate text B:

In abstract algebra, a field is a non-zero commutative ring that contains a multiplicative inverse for every nonzero element, or equivalently a ring whose nonzero elements form an abelian group under multiplication. As such it is an algebraic structure with notions of addition, subtraction, multiplication, and division satisfying the appropriate abelian group equations and distributive law. The most commonly used fields are the field of real numbers, the field of complex numbers, and the field of rational numbers, but there are also finite fields, fields of functions, algebraic number fields, p-adic fields, and so forth.

Any field may be used as the scalars for a vector space, which is the standard general context for linear algebra. The theory of field extensions including Galois theory involves the roots of polynomials with coefficients in a field; among other results, this theory leads to impossibility proofs for the classical problems of angle trisection and squaring the circle with a compass and straightedge, as well as a proof of the Abel-Ruffini theorem on the algebraic insolubility of quintic equations. In modem mathematics, the theory of fields (or field theory) plays an essential role in number theory and algebraic geometry.

As an algebraic structure, every field is a ring, but not every ring is a field. The most important difference is that fields allow for division (though not division by zero), while a ring need not possess multiplicative inverses; for example the integers form a ring, but 2x = 1 has no solution in integers. Also, the multiplication operation in a field is required to be commutative. A ring in which division is possible but commutativity is not assumed (such as the quaternions) is called a division ring or skew field. Historically, division rings were sometimes referred to as fields, while fields were called commutative fields.

As a ring, a field may be classified as a specific type of integral domain, and can be characterized by the following (not exhaustive) chain of class inclusions:

Commutative rings integral domains integrally closed domains unique factorization domains principal ideal domains Euclidean domains fields, finite fields.

The subject, first known as ideal theory, began with Richard Dedekind's work on ideals, itself based on the earlier work of Ernst Kummer and Leopold Kronecker. Later, David Hilbert introduced the term ring to generalize the earlier term number ring. Hilbert introduced a more abstract approach to replace the more concrete and computationally oriented methods grounded in such things as complex analysis and classical invariant theory. In turn, Hilbert strongly influenced Emmy Noether, who recast many earlier results in terms of an ascending chain condition, now known as the Noetherian condition. Another important milestone was the work of Hilbert's student Emanuel Lasker, who introduced primary ideals and proved the first version of the Lasker-Noether theorem.

The main figure responsible for the birth of commutative algebra as a mature subject was Wolfgang Krull, who introduced the fundamental notions of localization and completion of a ring, as well as that of regular local rings. He established the concept of the Krull dimension of a ring, first for Noetherian rings before moving on to expand his theory to cover general valuation rings and Krull rings. To this day, Krull's principal ideal theorem is widely considered the single most important foundational theorem in commutative algebra. These results paved the way for the introduction of commutative algebra into algebraic geometry, an idea which would revolutionize the latter subject.

Much of the modern development of commutative algebra emphasizes modules. Both ideals of a ring R and Я-algebras are special cases of i?-modules, so module theory encompasses both ideal theory and the theory of ring extensions. Though it was already incipient in Kronecker's work, the modem approach to commutative algebra using module theory is usually credited to Krull and Noether.

3.2.2 Fill in the gaps:

1 In abstract algebra, a field is _ _______ _______ ____ that contains a multiplicative inverse for every nonzero element, or equivalently _ ____ whose nonzero elements form an _____ ____ ____ ______. 2 Any field may be used as the ____ for a ____ ____, which is the standard general context for linear algebra. 3 The most important difference is that fields allow for _____, while a ring need not possess _____ _____. 4 Historically, ____ _____ were sometimes referred to as fields, while fields were called _____ _____. 5 Later, ____ ____ introduced the term ____ to generalize the earlier term ____ ____. 6 Wolfgang Krull introduced the fundamental notions of ____ ____ ____ ____ ____ ____, as well as that of ____ ____ ____. 7 Krull's principal ideal theorem is widely considered the single most important foundational theorem in ____ ____.

3.2.3 Answer the following questions:

1 What are the most commonly used fields? 2 What does the theory of field extension include? 3 How may field be classified as a ring? 4 What form did David Hilbert

introduce? 5 What were important milestones in algebra? 6 What does much of modern development of commutative algebra emphasize?

3.3 Random walks

3.3.1 Read and translate text C:

Example of eight random walks in one dimension starting at 0. The plot shows the current position on the line (vertical axis) versus the time steps (horizontal axis).

A random walk is a mathematical formalization of a path that consists of a succession of random steps. For example, the path traced by a molecule as it travels in a liquid or a gas, the search path of a foraging animal, the price of a fluctuating stock and the financial status of a gambler can all be modeled as random walks, although they may not be truly random in reality. The term random walk was first introduced by Karl Pearson in 1905. Random walks have been used in many fields: ecology, economics, psychology, computer science, physics, chemistry, and biology. Random walks explain the observed behaviors of many processes in these fields, and thus serve as a fundamental model for the recorded stochastic activity.

Various different types of random walks are of interest. Often, random walks are assumed to be Markov chains or Markov processes, but other, more complicated walks are also of interest. Some random walks are on graphs, others on the line, in the plane, in higher dimensions, or even curved surfaces, while some random walks are on groups. Random walks also vary with regard to the time parameter. Often, the walk is in discrete time, and indexed by the natural numbers, as in X\<X2<.... However, some walks take their steps at random times, and in that case the position adds defined for the continuum of times t > 0. Specific cases or limits of random walks include the L6vy flight. Random walks are related to the diffusion models and are a fundamental topic in discussions of Markov processes. Several properties of random walks, including dispersal distributions, first-passage times and encounter rates, have been extensively studied.

3.3.2 Translate words and word combinations into Russian:

random walk; vertical axis; succession of random steps; in reality; observed behaviors; stochastic activity; are of interest; are assumed to be chains; higher dimensions; curved surfaces; with the regard to the time; diffusion modes; dispersal distribution.

3.3.3 Answer the following questions:

1 What is random walk? 2 Give an example of random walk. 3 Who introduced term random walk? 4 Where have random walks been used? 5 What do random walks explain? 6 What are types of random walk?

3.4 Stochastic process

3.4.1 Read and translate text C:

Stock market fluctuations have been modeled by stochastic processes. In probability theory, a stochastic process, or often random process, is a collection of random variables, representing the evolution of some system of random values over time. This is the probabilistic counterpart to a deterministic process (or deterministic system). Instead of describing a process which can only evolve in one way (as in the case, for example, of solutions of an ordinary differential equation), in a stochastic or random process there is some indeterminacy: even if the initial condition (or starting point) is known, there are several (often infinitely many) directions in which the process may evolve.

In the simple case of discrete time, as opposed to continuous time, a stochastic process involves a sequence of random variables and the time series associated with these random variables (for example, see Markov chain, also known as discrete-time Markov chain). One approach to stochastic processes treats them as functions of one or several deterministic arguments (inputs; in most cases this will be the time parameter) whose values (outputs) are random variables: non- deterministic (single) quantities which have certain probability distributions. Random variables corresponding to various times (or points, in the case of random fields) may be completely different. The main requirement is that these different random quantities all take values in the same space (the codomain of the function). Although the random values of a stochastic process at different times may be independent random variables, in most commonly considered situations they exhibit complicated statistical correlations.

Familiar examples of processes modeled as stochastic time series include stock market and exchange rate fluctuations, signals such as speech, audio and video, medical data such as a patient's EKG, EEG, blood pressure or temperature, and random movement such as Brownian motion or random walks. Examples of random fields include static images, random terrain (landscapes), wind waves or composition variations of a heterogeneous material.

A generalization, the random field, is defined by letting the variables' parameters be members of a topological space instead of limited to real values representing time.

3.4.2 Give the definition of stochastic process.

3.4.3 Give the examples of process modeled as stochastic time series.

3.4.4 Ask 10 questions to the text D.

3.5 Algebraic geometry

3.5.1 Read and translate text E:

Algebraic geometry is a branch of mathematics, classically studying zeros of multivariate polynomial equations. Modem algebraic geometry is based on more abstract techniques of abstract algebra, especially commutative algebra, with the language and the problems of geometry.

The fundamental objects of study in algebraic geometry are algebraic varieties, which are geometric manifestations of solutions of systems of polynomial equations.

Examples of the most studied classes of algebraic varieties are: plane algebraic curves, which include lines, circles, parabolas, ellipses, hyperbolas, cubic curves like elliptic curves and quartic curves like lemniscates, and Cassini ovals. A point of the plane belongs to an algebraic curve if its coordinates satisfy a given polynomial equation. Basic questions involve the study of the points of special interest like the singular points, the inflection points and the points at infinity. More advanced questions involve the topology of the curve and relations between the curves given by different equations.

Algebraic geometry occupies a central place in modern mathematics and has multiple conceptual connections with such diverse fields as complex analysis, topology and number theory. Initially a study of systems of polynomial equations in several variables, the subject of algebraic geometry starts where equation solving leaves off, and it becomes even more important to understand the intrinsic properties of the totality of solutions of a system of equations, than to find a specific solution; this leads into some of the deepest areas in all of mathematics, both conceptually and in terms of technique.

In the 20th century, algebraic geometry has split into several subareas.

- The main stream of algebraic geometry is devoted to the study of the complex points of the algebraic varieties and more generally to the points with coordinates in an algebraically closed field.
- The study of the points of an algebraic variety with coordinates in the field of the rational numbers or in a number field became arithmetic geometry (or more classically Diophantine geometry), a subfield of algebraic number theory.
- The study of the real points of an algebraic variety is the subject of real algebraic geometry.
- A large part of singularity theory is devoted to the singularities of algebraic varieties.
- With the rise of the computers, a computational algebraic geometry area has emerged, which lies at the intersection of algebraic geometry and computer algebra. It consists essentially in developing algorithms and software for studying and finding the properties of explicitly given algebraic varieties.

3.5.2 Translate words and word combinations:

algebraic geometry; multivariate polynomial equations; commutative algebra solution; quartic curves; lemniscates; inflection points; infinity; has split; algebraic variety; singularity theory.

3.5.3 Give degrees of comparison of the following words:

abstract; studied; advanced; important; deep; classical; large.

3.5.4 Answer the following questions:

1 What is modern algebraic geometry based on? 2 What are the fundamental objects of study in algebraic geometry? 3 Give the examples of the most studied classes of algebraic varieties. 4 What has algebraic geometry split into in the 20th century?

4 Unit 4 Theories of Mathematics

4.1 Representation theory

4.1.1 Read and translate text A:

This article is about the theory of representations of algebraic structures by linear transformations and matrices. For representation theory in other disciplines, see Representation.

Representation theory is a branch of mathematics that studies abstract algebraic structures by representing their elements as linear transformations of vector spaces, and studies modules over these abstract algebraic structures. In essence, a representation makes an abstract algebraic object more concrete by describing its elements by matrices and the algebraic operations in terms of matrix addition and matrix multiplication. The algebraic objects amenable to such a description include groups, associative algebras and Lie algebras. The most prominent of these (and historically the first) is the representation theory of groups, in which elements of a group are represented by invertible matrices in such a way that the group operation is matrix multiplication.

Representation theory is a powerful tool because it reduces problems in abstract algebra to problems in linear algebra, a subject that is well understood [3]. Furthermore, the vector space on which a group (for example) is represented can be infinite-dimensional, and by allowing it to be, for instance, a Hilbert space, methods of analysis can be applied to the theory of groups. Representation theory is also important in physics because, for example, it describes how the symmetry group of a physical system affects the solutions of equations describing that system.

A striking feature of representation theory is its pervasiveness in mathematics. There are two sides to this. First, the applications of representation theory are diverse: in addition to its impact on algebra, representation theory:

— illuminates and vastly generalizes Fourier analysis via harmonic analysis,

— is deeply connected to geometry via invariant theory and the Erlangen program,

— has a profound impact in number theory via automorphic forms and the Langlands program.

The second aspect is the diversity of approaches to representation theory. The same objects can be studied using methods from algebraic geometry, module theory, analytic number theory, differential geometry, operator theory, algebraic combinatorics and topology.

The success of representation theory has led to numerous generalizations. One of the most general is in category theory. The algebraic objects to which representation theory applies can be viewed as particular kinds of categories, and the representations as functors from the object category to the category of vector spaces. This description points to two obvious generalizations: first, the algebraic objects can be replaced by more general categories; second, the target category of vector spaces can be replaced by other well-understood categories.

A representation should not be confused with a presentation.

4.1.2 Translate the following words and word combinations:

linear transformation of vector spaces; in terms of matrix; invertible matrices; pervaciveness in mathematics; connected via invariant theory; profound impact; diversity of approaches; category of vector spaces.

4.1.3 Find in the text definition of Representation theory, write it out and translate it in the written form.

4.1.4 Find in the text sentences with Participles, define their function and translate them.

4.1.5 Answer the following questions:

1 How does representation theory make an abstract algebraic object more concrete? 2 Why is representation theory a powerful tool? 3 What is the striking feature of representation theory? 4 What does representation theory do in addition to its impact on algebra? 5 What has the success of representation theory led to?

4.2 The mathematical theory of probability

4.2.1 Read and translate text B:

The mathematical theory of probability has its roots in attempts to analyze games of chance by Gerolamo Cardano in the sixteenth century, and by Pierre de Fermat and Blaise Pascal in the seventeenth century (for example the "problem of points"). Christiaan Huygens published a book on the subject in 1657 and in the 19th century a big work was done by Laplace in what can be considered today as the classic interpretation.

Initially, probability theory mainly considered discrete events, and its methods were mainly combinatorial. Eventually, analytical considerations compelled the incorporation of continuous variables into the theory.

This culminated in modern probability theory, on foundations laid by Andrey Nikolaevich Kholmogorov. Kholmogorov combined the notion of sample space, introduced by Richard von Mises, and measure theory and presented his axiom system for probability theory in 1933. Fairly quickly this became the mostly undisputed axiomatic basis for modern probability theory but alternatives exist, in particular the adoption of finite rather than countable additivity by Bruno de Finetti. Much of the development of the main stream of algebraic geometry in the 20th century occurred within an abstract algebraic framework, with increasing emphasis being placed on "intrinsic" properties of algebraic varieties not dependent on any particular way of embedding the variety in an ambient coordinate space; this parallels developments in topology, differential and complex geometry.

One key achievement of this abstract algebraic geometry is Grothendieck's scheme theory which allows one to use sheaf theory to study algebraic varieties in a way which is very similar to its use in the study of differential and analytic manifolds. This is obtained by extending the notion of point: In classical algebraic geometry, a point of an affine variety may be identified, through Hilbert's Nullstellensatz, with a maximal ideal of the coordinate ring, while the points of the corresponding affine scheme are all prime ideals of this ring. This means that a point of such a scheme may be either a usual point or a subvariety.

This approach also enables a unification of the language and the tools of classical algebraic geometry, mainly concerned with complex points, and of algebraic number theory. Wiles's proof of the longstanding conjecture called Fermat's last theorem is an example of the power of this approach.

4.2.2 Write out the mathematical terms and translate them.

4.2.3 Complete the table “Development of Probability Theory”

Name	Date	Scientific Work
Gerolamo Cardano	XVIIth century	Games of chances

4.3 Dynamical systems theory

4.3.1 Read and translate text C:

Dynamical systems theory is an area of mathematics used to describe the behavior of complex dynamical systems, usually by employing differential equations or difference equations. When differential equations are employed, the theory is called continuous dynamical systems. Wien difference equations are employed, the theory is called discrete dynamical systems. When the time variable runs over a set that is discrete over some intervals and continuous over other intervals or is any arbitrary time-set such as a cantor set- one gets dynamic equations on time scales. Some situations may also be modeled by mixed operators, such as differential-difference equations.

This theory deals with the long-term qualitative behavior of dynamical systems, and studies the solutions of the equations of motion of systems that are primarily mechanical in nature; although this includes both planetary orbits as well as the behaviour of electronic circuits and the solutions to partial differential equations that arise in biology. Much of modern research is focused on the study of chaotic systems.

This field of study is also called just Dynamical systems. Dynamical systems theory and chaos theory deal with the long-term qualitative behavior of dynamical systems. Here, the focus is not on finding precise solutions to the equations defining the dynamical system (which is often hopeless), but rather to answer questions like "Will the system settle down to a steady state in the long term, and if so, what are the possible steady states?", or "Does the long-term behavior of the system depend on its initial condition?"

An important goal is to describe the fixed points, or steady states of a given dynamical system; these are Values of the variable that don't change over time. Some of these fixed points are attractive, meaning that if the system starts out in a nearby state, it converges towards the fixed point.

Similarly, one is interested in the periodic points, slates of the system that repeat after several time steps. Periodic points can also be attractive. Sharkovski's theorem is an interesting statement about the number of periodic points of a one-dimensional discrete dynamical system.

Even simple nonlinear dynamical systems often exhibit seemingly random behavior that has been called chaos. The branch of dynamical systems that deals with the clean definition and investigation of chaos is called chaos theory.

The concept of dynamical systems theory has its origins in Newtonian mechanics. There, as in other natural sciences and engineering disciplines, the evolution rule of dynamical systems is given implicitly by a relation that gives the state of the system only a short time into the future.

Before the advent of fast computing machines, solving a dynamical system required sophisticated mathematical techniques and could only be accomplished for a small class of' dynamical systems.

The dynamical system concept is a mathematical formalization for any fixed "rule" that describes the time dependence of a point's position in its ambient space. Examples include the mathematical models that describe the swinging of a pendulum clock, the flow of water in a pipe, and the number of fish each spring in a lake.

4.3.2 Memorize the following word combinations. Write out sentences with them from the text and translate the sentences:

to deal with; to be focused on; to depend on; to be interested in.

4.3.3 Answer the following questions:

1 What is the dynamical system theory used to describe? 2 What does the theory deal with? 3 What is the important goal? 4 What do simple nonlinear dynamical systems often exhibit? 5 What is called chaos theory? 6 What has emerged with the rise of computers? 7 What is the dynamical system concept? 8 Give examples the dynamical system concept.

4.4 Group Theory

4.1.1 Read and translate text D:

In mathematics and abstract algebra, group theory studies the algebraic structures known as groups (Fig. 16). The concept of a group is central to abstract algebra: other well-known algebraic structures, such as rings, fields, and vector spaces, can all be seen as groups endowed with additional operations and axioms. Groups recur throughout mathematics, and the methods of group theory have influenced many parts of algebra. Linear algebraic groups and Lie groups are two branches of group theory that have experienced advances and have become subject areas in their own right.

Various physical systems, such as crystals and the hydrogen atom, may be modelled by symmetry groups. Thus group theory and the closely related representation theory have many important applications in physics, chemistry, and materials science. Group theory (Fig. 17) is also central to public key cryptography.

One of the most important mathematical achievements of the 20th century was the collaborative effort, taking up more than 10,000 journal pages and mostly published between 1960 and 1980, that culminated in a complete classification of finite simple groups.

Algebraic structure → Group theory

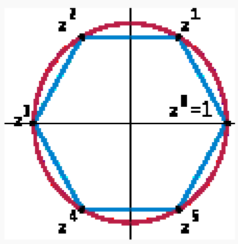


Figure 16 – Group theory

The range of groups being considered has gradually expanded from finite permutation groups and special examples of matrix groups to abstract groups that may be specified through a presentation by generators and relations.

Permutation groups

The first class of groups to undergo a systematic study was permutation groups. Given any set X and a collection G of bijections of X into itself (known as *permutations*) that is closed under compositions and inverses, G is a group acting on X. If X consists of n elements and G consists of *all* permutations, G is the symmetric group $S_n$in general, any permutation group G is a subgroup of the symmetric group of X. An early construction due to Cayley exhibited any group as a permutation group, acting on itself ($X = G$) by means of the left regular representation (Fig. 17).

In many cases, the structure of a permutation group can be studied using the properties of its action on the corresponding set. For example, in this way one proves that for $n \geq 5$, the alternating group A_n is simple, i.e. does not admit any proper normal subgroups. This fact plays a key role in the impossibility of solving a general algebraic equation of degree $n' \geq 5$ *in radicals*.

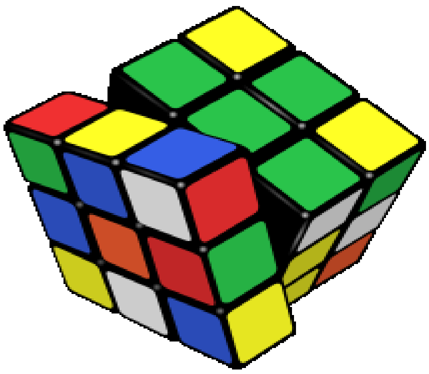


Figure 17– The popular puzzle Rubik's cube invented in 1974 by Ernő Rubik has been used as an illustration of permutation groups

Matrix groups

The next important class of groups is given by *matrix groups*, or linear groups. Here G is a set consisting of invertible matrices of given order n over a field K that is closed under the products and inverses. Such a group acts on the n-dimensional vector space K^n by linear transformations. This action makes matrix groups conceptually similar to permutation groups, and the geometry of the action may be usefully exploited to establish properties of the group G.

Transformation groups

Permutation groups and matrix groups are special cases of transformation groups: groups that act on a certain space X preserving its inherent structure. In the case of permutation groups, X is a set; for matrix groups, X is a vector space. The concept of a transformation group is closely related with the concept of a symmetry group: transformation groups frequently consist of *all* transformations that preserve a certain structure.

The theory of transformation groups forms a bridge connecting group theory with differential geometry. A long line of research, originating with Lie and Klein, considers group actions on manifolds by homeomorphisms or diffeomorphisms. The groups themselves may be discrete or continuous.

Abstract groups

Most groups considered in the first stage of the development of group theory were "concrete", having been realized through numbers, permutations, or matrices. It was not until the late nineteenth century that the idea of an abstract group as a set with operations satisfying a certain system of axioms began to take hold.

A significant source of abstract groups is given by the construction of a *factor group*, or quotient group, G/H, of a group G by a normal subgroup H. Class groups of algebraic number fields were among the earliest examples of factor groups, of much interest in number theory. If a group G is a permutation group on a set X, the factor group G/H is no longer acting on X; but the idea of an abstract group permits one not to worry about this discrepancy.

The change of perspective from concrete to abstract groups makes it natural to consider properties of groups that are independent of a particular realization, or in modern language, invariant under isomorphism, as well as the classes of group with a given such property: finite groups, periodic groups, simple groups, solvable groups, and so on. Rather than exploring properties of an individual group, one seeks to establish results that apply to a whole class of groups. The new paradigm was of paramount importance for the development of mathematics: it foreshadowed the creation of abstract algebra in the works of Hilbert, Emil Artin, Emmy Noether, and mathematicians of their school.

Topological and algebraic groups

An important elaboration of the concept of a group occurs if G is endowed with additional structure, notably, of a topological space, differentiable manifold, or algebraic variety.

The presence of extra structure relates these types of groups with other mathematical disciplines and means that more tools are available in their study. Topological groups form a natural domain for abstract harmonic analysis, whereas Lie groups (frequently realized as transformation groups) are the mainstays of differential geometry and unitary representation theory. Certain classification questions that cannot be solved in general can be approached and resolved for special subclasses of groups. Thus, compact connected Lie groups have been completely classified. There is a fruitful relation between infinite abstract groups and topological groups: whenever a group Γ can be realized as a lattice in a topological group G, the geometry and analysis pertaining to G yield important results about Γ. A comparatively recent trend in the theory of finite groups exploits their connections with compact topological groups (profinite groups): for example, a single p-adic analytic group G has a family of quotients which are finite p-groups of various orders, and properties of G translate into the properties of its finite quotients.

Finite group theory

During the twentieth century, mathematicians investigated some aspects of the theory of finite groups in great depth, especially the local theory of finite groups and the theory of solvable and nilpotent groups. As a consequence, the complete classification of finite simple groups was achieved, meaning that all those simple groups from which all finite groups can be built are now known.

During the second half of the twentieth century, mathematicians such as Chevalley and Steinberg also increased our understanding of finite analogs of classical groups, and other related groups. One such family of groups is the family of general linear groups over finite fields. Finite groups often occur when considering symmetry of mathematical or physical objects, when those objects admit just a finite number of structure-preserving transformations. The theory of Lie groups, which may be viewed as dealing with "continuous symmetry", is strongly influenced by the associated Weyl groups. These are finite groups generated by reflections which act on a finite-dimensional Euclidean space. The properties of finite groups can thus play a role in subjects such as theoretical physics and chemistry.

Representation of groups

Saying that a group G *acts* on a set X, means that every element of G defines a bijective map on the set X in a way compatible with the group structure. When X has more structure, it is useful to restrict this notion further: a representation of G on a vector space V is a group homomorphism:$\rho : G \to \mathrm{GL}(V)$,where $\mathrm{GL}(V)$ consists of the invertible linear transformations of V. In other words, to every group element g is assigned an automorphism $\rho(g)$ such that $\rho(g) \circ \rho(h) = \rho(gh)$ for any h in G.

This definition can be understood in two directions, both of which give rise to whole new domains of mathematics. On the one hand, it may yield new information about the group G: often, the group operation in G is abstractly given, but via ρ, it corresponds to the multiplication of matrices, which is very explicit. On the other hand, given a well-understood group acting on a complicated object, this simplifies the study of the object in question. For example, if G is finite, it is known that V above decomposes into irreducible parts. These parts in turn are much more easily manageable than the whole V (via Schur's lemma).

Given a group G, representation theory then asks what representations of G exist. There are several settings, and the employed methods and obtained results are rather different in every case: representation theory of finite groups and representations of Lie groups are two main subdomains of the theory. The totality of representations is governed by the group's characters. For example, Fourier polynomials can be interpreted as the characters of U, the group of complex numbers of absolute value 1, acting on the L^2-space of periodic functions.

Lie theory

A Lie group is a group that is also a differentiable manifold, with the property that the group operations are compatible with the smooth structure. Lie groups are named after Sophus Lie, who laid the foundations of the theory of continuous transformation groups. The term *groupes de Lie* first appeared in French in 1893 in the thesis of Lie's student Arthur Tresse.

Lie groups represent the best-developed theory of continuous symmetry of mathematical objects and structures, which makes them indispensable tools for many parts of contemporary mathematics, as well as for modern theoretical physics. They provide a natural framework for analyzing the continuous symmetries of differential equations(differential Galois theory), in much the same way as permutation groups are used in Galois theory for analyzing the discrete symmetries of algebraic equations. An extension of Galois theory to the case of continuous symmetry groups was one of Lie's principal motivations.

Combinatorial and geometric group theory

Groups can be described in different ways. Finite groups can be described by writing down the group table consisting of all possible multiplications g h. A more compact way of defining a group is by *generators and relations*, also called the *presentation* of a group. Given any set F of generators $\{g_i\}_{i \in I}$, the free group generated by F subjects onto the group G. The kernel of this map is called subgroup of relations, generated by some subset D. The presentation is usually denoted by $\langle F \mid D \rangle$. For example, the group Z = $\langle a| \rangle$ can be generated by one element a (equal to +1 or −1) and no relations, because $n \cdot 1$ never equals 0 unless n is zero. A string consisting of generator symbols and their inverses is called a *word*.

Combinatorial group theory studies groups from the perspective of generators and relations. It is particularly useful where finiteness assumptions are satisfied, for example finitely generated groups, or finitely presented groups (i.e. in addition the relations are finite). The area makes use of the connection of graphs via their fundamental groups. For example, one can show that every subgroup of a free group is free.

There are several natural questions arising from giving a group by its presentation. The *word problem* asks whether two words are effectively the same group element. By relating the problem to Turing machines, one can show that there is in general no algorithm solving this task. Another, generally harder, algorithmically insoluble problem is the group isomorphism problem, which asks whether two groups given by different presentations are actually isomorphic.

Geometric group theory attacks these problems from a geometric viewpoint, either by viewing groups as geometric objects, or by finding suitable geometric objects a group acts on. The first idea is made precise by means of the Cayley graph (Fig. 18), whose vertices correspond to group elements and edges correspond to right multiplication in the group. Given two elements, one constructs the word metric given by the length of the minimal path between the elements. A theorem of Milnor and Svarc then says that given a group *G* acting in a reasonable manner on a metric space *X*, for example a compact manifold, then *G* is quasi-isometric (i.e. looks similar from a distance) to the space *X*.

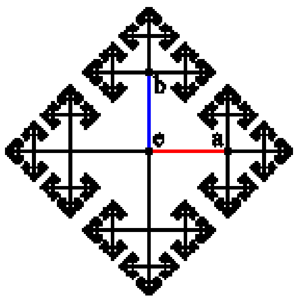


Figure 18 – The Cayley graph of ⟨ x, y ∣⟩, the free group of rank 2

Connection of groups and symmetry

Given a structured object *X* of any sort, a symmetry is a mapping of the object onto itself which preserves the structure. This occurs in many cases, for example

1 If *X* is a set with no additional structure, a symmetry is a bijective map from the set to itself, giving rise to permutation groups.

2 If the object *X* is a set of points in the plane with its metric structure or any other metric space, a symmetry is a bijection of the set to itself which preserves the distance

between each pair of points (an isometry). The corresponding group is called isometry group of X.

3 If instead angles are preserved, one speaks of conformal maps. Conformal maps give rise to Kleinian groups, for example.

4 Symmetries are not restricted to geometrical objects, but include algebraic objects as well. For instance, the equation $x^2 - 3 = 0$ has two solutions $+\sqrt{3}$, and $-\sqrt{3}$. In this case, the group that exchanges the two roots is the Galois group belonging to the equation. Every polynomial equation in one variable has a Galois group that is a certain permutation group on its roots.

The axioms of a group formalize the essential aspects of symmetry. Symmetries form a group: they are closed because if you take a symmetry of an object, and then apply another symmetry, the result will still be a symmetry. The identity keeping the object fixed is always a symmetry of an object. Existence of inverses is guaranteed by undoing the symmetry and the associativity comes from the fact that symmetries are functions on a space, and composition of functions are associative.

Frucht's theorem says that every group is the symmetry group of some graph. So every abstract group is actually the symmetries of some explicit object.

The saying of "preserving the structure" of an object can be made precise by working in a category. Maps preserving the structure are then the morphisms, and the symmetry group is the automorphism group of the object in question.

Applications of group theory abound. Almost all structures in abstract algebra are special cases of groups. Rings, for example, can be viewed as abelian groups (corresponding to addition) together with a second operation (corresponding to multiplication). Therefore, group theoretic arguments underlie large parts of the theory of those entities.

Galois theory

Galois theory uses groups to describe the symmetries of the roots of a polynomial (or more precisely the automorphisms of the algebras generated by these roots). The fundamental theorem of Galois theory provides a link between algebraic field extensions and group theory. It gives an effective criterion for the solvability of polynomial equations in terms of the solvability of the corresponding Galois group. For example, S_5, the symmetric group in 5 elements, is not solvable which implies that the general quintic equation cannot be solved by radicals in the way equations of lower degree can. The theory, being one of the historical roots of group theory, is still fruitfully applied to yield new results in areas such as class field theory.

Algebraic topology

Algebraic topology is another domain which prominently associates groups to the objects the theory is interested in. There, groups are used to describe certain invariants of topological spaces. They are called "invariants" because they are defined in such a way that they do not change if the space is subjected to some deformation. For example, the fundamental group "counts" how many paths in the space are essentially different. The Poincaré conjecture, proved in 2002/2003 by Grigori Perelman, is a prominent application of this idea. The influence is not unidirectional, though. For example, algebraic topology makes use of Eilenberg–MacLane spaces which are spaces with prescribed homotopy groups. Similarly algebraic K-theory relies in a way on classifying spaces of groups. Finally, the name of the torsion subgroup of an infinite group shows the legacy of topology in group theory (Fig. 19).

Algebraic geometry and cryptography likewise uses group theory in many ways. Abelian varieties have been introduced above. The presence of the group operation yields additional information which makes these varieties particularly accessible. They also often serve as a test for new conjectures. The one-dimensional case, namely elliptic curves is studied in particular detail. They are both theoretically and practically intriguing. Very large groups of prime order constructed in Elliptic-Curve Cryptography serve for public key cryptography. Cryptographical methods of this kind benefit from the flexibility of the geometric objects, hence their group structures, together with the complicated structure of these groups, which make the discrete logarithm very hard to calculate. One of the earliest encryption protocols, Caesar's cipher (Fig. 20), may also be interpreted as a (very easy) group operation. In another direction, toric varieties are algebraic varieties acted on by a torus. Toroidal embeddings have recently led to advances in algebraic geometry, in particular resolution of singularities.

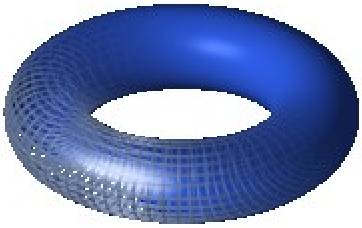


Figure 19 – A torus. Its abelian group structure is induced from the map C → C/Z + τZ, where τ is a parameter living in the upper half plane

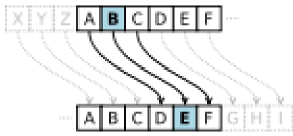


Figure 20 – The cyclic group Z 26 underlies Caesar's cipher

Algebraic number theory

Algebraic number theory is a special case of group theory, thereby following the rules of the latter. For example, Euler's product formula captures the fact that any integer decomposes in a unique way into primes.

The failure of this statement for more general rings gives rise to class groups and regular primes, which feature in Kummer's treatment of Fermat's Last Theorem.

Harmonic analysis

Harmonic analysis on Lie groups and certain other groups is called harmonic analysis. Haar measures, that is, integrals invariant under the translation in a Lie group, are used for pattern recognition and other image processing techniques.

Combinatorics

In combinatorics (Fig. 21), the notion of permutation group and the concept of group action are often used to simplify the counting of a set of objects; see in particular Burnside's lemma.

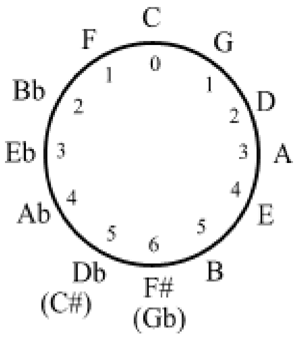


Figure 21 – The circle of fifths may be endowed with a cyclic group structure

Physics

In physics groups are important because they describe the symmetries which the laws of physics seem to obey. According to Noether's theorem, every continuous symmetry of a physical system corresponds to a conservation law of the system. Physicists are very interested in group representations, especially of Lie groups, since these representations often point the way to the "possible" physical theories. Examples of the use of groups in physics include the Standard Model, gauge theory, the Lorentz group, and the Poincaré group.

Chemistry and materials science

In chemistry and materials science, groups are used to classify crystal structures, regular polyhedra, and the symmetries of molecules. The assigned point groups can then be used to determine physical properties (such as polarity and chirality), spectroscopic properties particularly useful for Raman spectroscopy and infrared spectroscopy and to construct molecular orbitals.

Molecular symmetry is responsible for many physical and spectroscopic properties of compounds and provides relevant information about how chemical reactions occur. In order to assign a point group for any given molecule, it is necessary to find the set of symmetry operations present on it. The symmetry operation is an action, such as a rotation around an axis or a reflection through a mirror plane. In other words, it is an operation that moves the molecule such that it is indistinguishable from the original configuration. In group theory, the rotation axes and mirror planes are called "symmetry elements". These elements can be a point, line or plane with respect to which the symmetry operation is carried out. The symmetry operations of a molecule determine the specific point group for this molecule (Fig. 22).

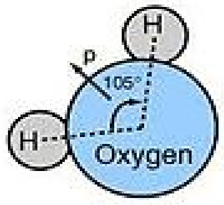


Figure 22 – Water molecule with symmetry axis

In chemistry, there are five important symmetry operations. The identity operation (E) consists of leaving the molecule as it is. This is equivalent to any number of full rotations around any axis. This is a symmetry of all molecules, whereas the symmetry group of a chiral molecule consists of only the identity operation. Rotation around an axis (C_n) consists of rotating the molecule around a specific axis by a specific angle. For example, if a water molecule rotates 180° around the axis that passes through the oxygen atom and between the hydrogen atoms, it is in the same configuration as it started. In this case, $n = 2$, since applying it twice produces the identity operation. Other symmetry operations are: reflection, inversion and improper rotation (rotation followed by reflection).

Statistical Mechanics

Group theory can be used to resolve the incompleteness of the statistical interpretations of mechanics developed by Willard Gibbs, relating to the summing of an infinite number of probabilities to yield a meaningful solution

Group theory has three main historical sources: number theory, the theory of algebraic equations, and geometry. The number-theoretic strand was begun by Leonhard Euler, and developed by Gauss's work on modular arithmetic and additive and multiplicative groups related to quadratic fields. Early results about permutation groups were obtained by Lagrange, Ruffini, and Abel in their quest for general solutions of polynomial equations of high degree. Évariste Galois coined the term "group" and established a connection, now known as Galois theory, between the nascent theory of groups and field theory. In geometry, groups first became important in projective geometry and, later, non-Euclidean geometry. Felix Klein's Erlangen program proclaimed group theory to be the organizing principle of geometry.

Galois, in the 1830s, was the first to employ groups to determine the solvability of polynomial equations. Arthur Cayley and Augustin Louis Cauchy pushed these investigations further by creating the theory of permutation groups. The second historical source for groups stems from geometrical situations. In an attempt to come to grips with possible geometriessuch as euclidean, hyperbolic or projective geometry using group theory, Felix Klein initiated the Erlangen programme. Sophus Lie, in 1884, started using groups now called Lie groups attached to analytic problems. Thirdly, groups were, at first implicitly and later explicitly, used in algebraic number theory.

The different scope of these early sources resulted in different notions of groups. The theory of groups was unified starting around 1880. Since then, the impact of group theory has been ever growing, giving rise to the birth of abstract algebra in the early 20th century, representation theory, and many more influential spin-off domains. The classification of finite simple groups is a vast body of work from the mid 20th century, classifying all the finite simple groups.

4.4.2 Generate formulas:

- specifying an abstract group through presentation by generators and relations;
- group operations m(multiplication) and i(inversion);
- Euler's product formula.

4.4.3 Write out types of groups mentioned in the text and translate them.

4.4.4 Translate the sentences and determine the predicate time:

1 In mathematics and abstract algebra, group theory studies the algebraic structures known as groups. 2 Various physical systems, such as crystals and the hydrogen atom, may be modelled by symmetry groups. 3 One of the most important mathematical

achievements of the 20th century was the collaborative effort, that culminated in a complete classification of finite simple groups. 4 The range of groups has gradually expanded from finite permutation groups and special examples of matrix groups to abstract groups. 5 This definition can be understood in two directions, both of which give rise to whole new domains of mathematics. 6 The totality of representations is governed by the group's characters. 7 Toroidal embeddings have recently led to advances in algebraic geometry, in particular resolution of singularities. 8 Group theory has three main historical sources: number theory, the theory of algebraic equations, and geometry.

4.4.5 Write the summary of the text D.

5 Unit 5 Combinatorics

5.1 Combinatorics

5.1.1 Read and translate text A:

Combinatorics is a branch of mathematics concerning the study of finite or countable discrete structures. Aspects of combinatorics include counting the structures of a given kind and size (enumerative combinatorics), deciding when certain criteria can be met, and constructing and analyzing objects meeting the criteria (as in combinatorial designs and matroid theory), finding "largest", "smallest", or "optimal" objects (extremal combinatorics and combinatorial optimization), and studying combinatorial structures arising in an algebraic context, or applying algebraic techniques to combinatorial problems (algebraic combinatorics).

Combinatorial problems arise in many areas of pure mathematics, notably in algebra, probability theory, topology, and geometry, and combinatorics also has many applications in mathematical optimization, computer science, ergodic theory and statistical physics. Many combinatorial questions have historically been considered in isolation, giving an ad hoc solution to a problem arising in some mathematical context. In the later twentieth century, however, powerful and general theoretical methods were developed, making combinatorics into an independent branch of mathematics in its own right. One of the oldest and most accessible parts of combinatorics is graph theory, which also has numerous natural connections to other areas. Combinatorics is used frequently in computer science to obtain formulas and estimates in the analysis of algorithms.

A mathematician who studies combinatorics is called a combinatorialist or a combinatorist.

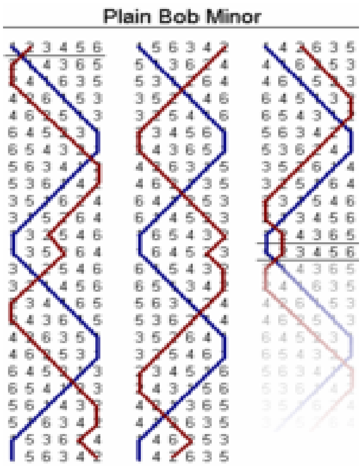


Figure 23 – An example of change ringing (with six bells)

5.1.2 Translate the following word combinations;

discrete structures; finite or countable; enumerative combinatorics; when certain criteria can be met; ergodic theory; graph theory; independent branch.

5.1.3 Answer the following questions:

1 What is combinatorics? 2 What do the aspects of combinatorics include? 3 Where do the combinatorical problems arise? 4 What is one of the oldest and most accessible parts of combinatorics? 5 Where is combinatorics frequently used?

5.1.4 Ask 5 types of questions to the text.

5.2 History of combinatorics

5.2.1 Read and translate text B:

Basic combinatorial concepts and enumerative results appeared throughout the ancient world. In 6th century BCE, ancient Indian physician Sushruta asserts in Sushruta Samhita that 63 combinations can be made out of 6 different tastes, taken one at a time, two at a time, etc., thus computing all $2^6 - 1$ possibilities. Greek historian Plutarch discusses an argumentbetween Chrysippus (3rd century BCE) and Hipparchus (2nd century BCE) of a rather delicate enumerative problem, which was later shown to be related to Schröder numbers. In the Ostomachion, Archimedes (3rd century BCE) considers a tiling puzzle.

In the Middle Ages, combinatorics continued to be studied, largely outside of the European civilization. The Indian mathematician Mahāvīra provided formulae for the number of permutations and combinations, and these formulas may have been familiar to Indian mathematicians as early as the 6th century CE. The philosopher and astronomer Rabbi Abraham ibn Ezra established the symmetry of binomial coefficients, while a closed formula was obtained later by the talmudist and mathematician Levi ben Gerson (better known as Gersonides), in 1321. The arithmetical triangle — a graphical diagram showing relationships among the binomial coefficients — was presented by mathematicians in treatises dating as far back as the 10th century, and would eventually become known as Pascal's triangle. Later, in Medieval England, campanology provided examples of what is now known as Hamiltonian cycles in certain Cayley graphs on permutations.

During the Renaissance, together with the rest of mathematics and the sciences, combinatorics enjoyed a rebirth. Works of Pascal, Newton, Jacob Bernoulli and Euler became foundational in the emerging field. In modern times, the works of J. J. Sylvester (late 19th century) and Percy MacMahon (early 20th century) helped lay the foundation for enumerative and algebraic combinatorics. Graph theory also enjoyed an explosion of interest at the same time, especially in connection with the four color problem.

In the second half of 20th century, combinatorics enjoyed a rapid growth, which led to establishment of dozens of new journals and conferences in the subject. In part, the growth was spurred by new connections and applications to other fields, ranging from algebra to probability, from functional analysis to number theory, etc. These connections shed the boundaries between combinatorics and parts of mathematics and theoretical computer science, but at the same time led to a partial fragmentation of the field.

5.2.2 Translate the following word combinations:

enumerative results; ancient world; BC; Renaissance; Medieval England; cycles; permutations; to lay the foundation; exposition of interest; enjoyed a rebirth; at the same time.

5.2.3 Speak about the development of combinatorics in BC, Middle Ages, Renaissance, 20^{th} century.

5.3 Approaches and subfields of combinatorics

5.3.1 Read and translate text A:

Enumerative combinatorics is the most classical area of combinatorics, and concentrates on counting the number of certain combinatorial objects (Fig. 24). Although counting the number of elements in a set is a rather broad mathematical problem, many of the problems that arise in applications have a relatively simple combinatorial description. Fibonacci numbers is the basic example of a problem in enumerative combinatorics. The twelvefold way provides a unified framework for counting permutations, combinations and partitions.

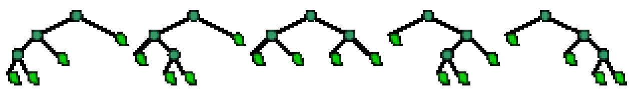


Figure 24 – Five binary trees on three vertices, an example of Catalan numbers

Analytic combinatorics concerns the enumeration of combinatorial structures using tools from complex analysis and probability theory. In contrast with enumerative combinatorics, which uses explicit combinatorial formulae and generating functions to describe the results, analytic combinatorics aims at obtaining asymptotic formulae.

Partition theory (Fig. 25) studies various enumeration and asymptotic problems related to integer partitions, and is closely related to q-series, special functions and orthogonal polynomials. Originally a part of number theory and analysis, it is now considered a part of combinatorics or an independent field. It incorporates the bijective approach and various tools in analysis, analytic number theory, and has connections with statistical mechanics.

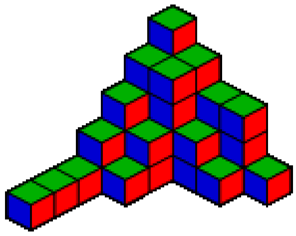


Figure 25 – A plane partition / Partition theory

Graph theory

Graphs are basic objects in combinatorics (Fig. 26). The questions range from counting (e.g., the number of graphs on n vertices with k edges) to structural (e.g., which graphs contain Hamiltonian cycles) to algebraic questions (e.g., given a graph G and two numbers x and y, does the Tutte polynomial$T_G(x, y)$ have a combinatorial interpretation?. It should be noted that while there are very strong connections between graph theory and combinatorics, these two are sometimes thought of as separate subjects. This is due to the fact that while combinatorial methods apply to many graph theory problems, the two are generally used to seek solutions to different problems.

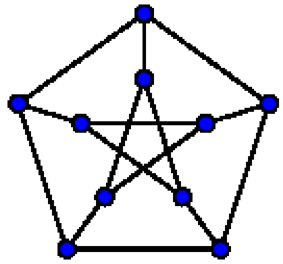


Figure 26 – Petersen graph

Design theory is a study of combinatorial designs, which are collections of subsets with certain intersection properties. Block designs are combinatorial designs of a special type. This area is one of the oldest parts of combinatorics, such as in Kirkman's schoolgirl problem proposed in 1850. The solution of the problem is a special case of a Steiner system, which systems play an important role in the classification of finite simple groups. The area has further connections to coding theory and geometric combinatorics.

Finite geometry is the study of geometric systems having only a finite number of points. Structures analogous to those found in continuous geometries (Euclidean plane, real projective space, etc.) but defined combinatorially are the main items studied. This area provides a rich source of examples for design theory. It should not be confused with discrete geometry (combinatorial geometry).

Order theory is the study of partially ordered sets, both finite and infinite (Fig. 27). Various examples of partial orders appear in algebra, geometry, number theory and throughout combinatorics and graph theory. Notable classes and examples of partial orders include lattices and Boolean algebras

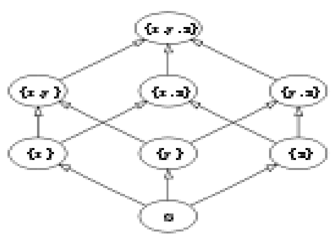


Figure 27 – Hasse diagram of thepowerset of {x, y, z} ordered by inclusion

Matroid theory abstracts part of geometry. It studies the properties of sets (usually, finite sets) of vectors in a vector space that do not depend on the particular coefficients in a linear dependence relation. Not only the structure but also enumerative properties belong to matroid theory. Matroid theory was introduced by Hassler Whitney and studied as a part of the order theory. It is now an independent field of study with a number of connections with other parts of combinatorics.

Extremal combinatorics studies extremal questions on set systems. The types of questions addressed in this case are about the largest possible graph which satisfies certain properties. For example, the largest triangle-free graph on 2n vertices is a complete bipartite graph $K_{n,n}$. Often it is too hard even to find the extremal answer f(n) exactly and one can only give an asymptotic estimate.

Ramsey theory is another part of extremal combinatorics. It states that any sufficiently large configuration will contain some sort of order. It is an advanced generalization of the pigeonhole principle.

In **probabilistic combinatorics**, the questions are of the following type: what is the probability of a certain property for a random discrete object, such as a random graph? For instance, what is the average number of triangles in a random graph? Probabilistic methods are also used to determine the existence of combinatorial objects with certain prescribed properties (for which explicit examples might be difficult to find), simply by observing that the probability of randomly selecting an object with those properties is greater than 0. This approach (often referred to as the probabilistic method) proved highly effective in applications to extremal combinatorics and graph theory (Fig. 28). A closely related area is the study of finite Markov chains, especially on combinatorial objects. Here again probabilistic tools are used to estimate the mixing time.

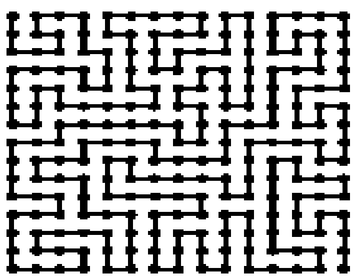


Figure 28 – Self-avoiding walk in asquare grid graph

Often associated with Paul Erdős, who did the pioneer work on the subject, probabilistic combinatorics was traditionally viewed as a set of tools to study problems in other parts of combinatorics. However, with the growth of applications to analysis of algorithms in computer science, as well as classical probability, additive and probabilistic number theory, the area recently grew to become an independent field of combinatorics.

Algebraic combinatorics is an area of mathematics that employs methods of abstract algebra, notably group theory and representation theory, in various combinatorial contexts and, conversely, applies combinatorial techniques to problems in algebra (Fig. 29). Algebraic combinatorics is continuously expanding its scope, in both topics and techniques, and can be seen as the area of mathematics where the interaction of combinatorial and algebraic methods is particularly strong and significant.

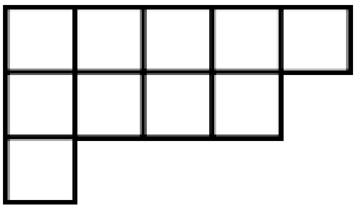


Figure 29 – Young diagram of a partition (5, 4, 1)

Combinatorics on words deals with formal languages. It arose independently within several branches of mathematics, including number theory, group theory and probability. It has applications to enumerative combinatorics, fractal analysis, theoretical computer science,automata theory and linguistics. While many applications are new, the classical Chomsky–Schützenberger hierarchy of classes of formal grammars is perhaps the best known result in the field.

Geometric combinatorics is related to convex and discrete geometry, in particular polyhedral combinatorics. It asks, for example, how many faces of each dimension can a convex polytope have. Metric properties of polytopes play an important role as well, e.g. the Cauchy theorem on rigidity of convex polytopes. Special polytopes are also considered, such as permutohedra, associahedra and Birkhoff polytopes (Fig. 30). We should note that combinatorial geometry is an old fashioned name for discrete geometry.

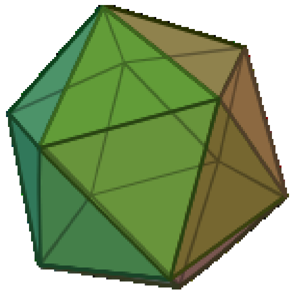


Figure 30 – An icosahedron

Topological combinatorics. Combinatorial analogs of concepts and methods in topology are used to study graph coloring, fair division, partitions, partially ordered sets, decision trees, necklace problems and discrete Morse theory. It should not be confused with combinatorial topology which is an older name for algebraic topology (Fig. 31).

Arithmetic combinatorics arose out of the interplay between number theory, combinatorics, ergodic theory and harmonic analysis. It is about combinatorial estimates associated with arithmetic operations (addition, subtraction, multiplication, and division). Additive combinatorics refers to the special case when only the operations of addition and subtraction are involved. One important technique in arithmetic combinatorics is theergodic theory of dynamical systems.

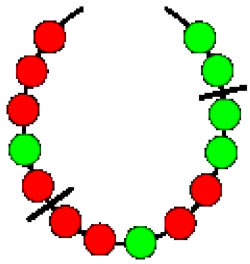


Figure 31 – Splitting a necklace with two cuts

Infinitary combinatorics, or combinatorial set theory, is an extension of ideas in combinatorics to infinite sets. It is a part of set theory, an area of mathematical logic, but uses tools and ideas from both set theory and extremal combinatorics.

Gian-Carlo Rota used the name continuous combinatorics to describe probability and measure theory, since there are many analogies between counting and measure (Fig. 32).

Related fields

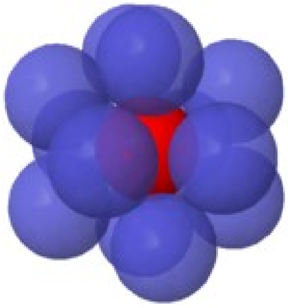


Figure 32 – Kissing spheres are connected to both coding theory and discrete geometry

Combinatorial optimization is the study of optimization on discrete and combinatorial objects. It started as a part of combinatorics and graph theory, but is now viewed as a branch of applied mathematics and computer science, related to operations research, algorithm theory and computational complexity theory.

Coding theory started as a part of design theory with early combinatorial constructions of error-correcting codes. The main idea of the subject is to design efficient and reliable methods of data transmission. It is now a large field of study, part of information theory.

Discrete and computational geometry. Discrete geometry (also called combinatorial geometry) also began a part of combinatorics, with early results on convex polytopes and kissing numbers. With the emergence of applications of discrete geometry to computational geometry, these two fields partially merged and became a separate field of study. There remain many connections with geometric and topological combinatorics, which themselves can be viewed as outgrowths of the early discrete geometry.

5.3.2 Write out and translate the names of subfields of combinatorics mentioned in the text.

5.3.3 Find in the text English equivalents to the following Russian ones:

перечислительная комбинаторика; явные комбинаторные формулы; биективный подход; теория порядка; решетки; предписанные свойства; имеет дело с формальными языками; ассоциадры; коды исправления ошибок.

5.3.4 Answer the following questions:

1 What does enumerative combinatorics concentrate on? 2 What does analytic combinatorics concern? 3 What does the partition theory study? 4 What do questions in graphs range to? 5 What is the design theory? 6 What is the finite geometry? 7 What is the order theory? 8 What does matroid theory study? 9 What does extremal combinatorics study? 10 What are the questions in probabilistic combinatorics? 11 What methods does algebraic combinatorics employ? 12 What does combinatorics on words deal with? 13 What is geometric combinatorics related to? 14 What are combinatorial analogs of concepts and methods in topology used to? 15 What is infinitary combinatorics? 16 What is the main idea of coding theory?

6 Unit 6 Prominent Scientists

6.1 Albert Einstein

6.1.1 Read and translate text A:

Albert Einstein was a German-born theoretical physicist. He developed the general theory of relativity, one of the two pillars of modern physics (alongside quantum mechanics). Einstein's work is also known for its influence on the philosophy of science. Einstein is best known in popular culture for his mass–energy equivalence formula $E = mc^2$ (which has been dubbed "the world's most famous equation").He received the 1921

Nobel Prize in Physics for his "services to theoretical physics", in particular his discovery of the law of the photoelectric effect, a pivotal step in the evolution of quantum theory.

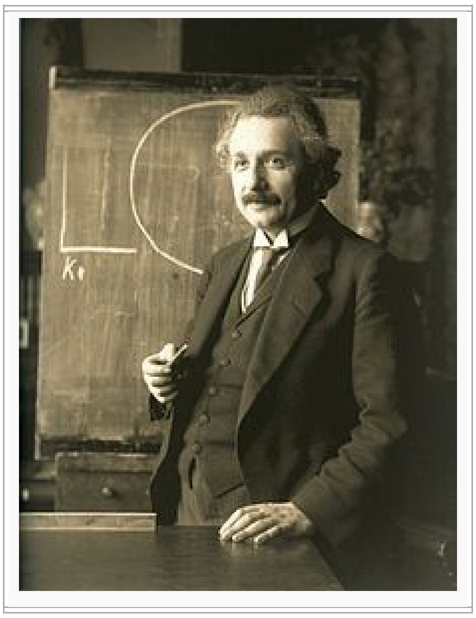


Figure 33 – Albert Einstein (1879-1955)

Near the beginning of his career, Einstein thought that Newtonian mechanics was no longer enough to reconcile the laws of classical mechanics with the laws of the electromagnetic field. This led to the development of his special theory of relativity. He realized, however, that the principle of relativity could also be extended to gravitational fields, and with his subsequent theory of gravitation in 1916, he published a paper on general relativity. He continued to deal with problems of statistical mechanics and quantum theory, which led to his explanations of particle theory and the motion of molecules. He also investigated the thermal properties of light which laid the foundation of the photon theory of light. In 1917, Einstein applied the general theory of relativity to model the large-scale structure of the universe.

He was visiting the United States when Adolf Hitler came to power in 1933 and, being Jewish, did not go back to Germany, where he had been a professor at the Berlin Academy of Sciences. He settled in the U.S., becoming an American citizen in 1940. On the eve of World War II, he endorsed a letter to President Franklin D. Roosevelt alerting him to the potential development of "extremely powerful bombs of a new type" and recommending that the U.S. begin similar research. This eventually led to what would become the Manhattan Project. Einstein supported defending the Allied forces, but largely denounced the idea of using the newly discovered nuclear fission as a weapon. Later, with the British philosopher Bertrand Russell, Einstein signed the Russell–Einstein Manifesto, which highlighted the danger of nuclear weapons. Einstein was affiliated with the Institute for Advanced Study in Princeton, New Jersey, until his death in 1955.

Einstein published more than 300 scientific papers along with over 150 non-scientific works. On 5 December 2014, universities and archives announced the release of Einstein's papers, comprising more than 30,000 unique documents. Einstein's intellectual achievements and originality have made the word "Einstein" synonymous with "genius".

Early life and education

Albert Einstein was born in Ulm, in the Kingdom of Württemberg in the German Empire on 14 March 1879. His parents were Hermann Einstein, a salesman and engineer, and Pauline Koch. In 1880, the family moved to Munich, where Einstein's father and his uncle Jakob founded *Elektrotechnische Fabrik J. Einstein & Cie*, a company that manufactured electrical equipment based on direct current.

The Einsteins were non-observant Ashkenazi Jews, and Albert attended a Catholic elementary school from the age of 5 for three years. At the age of 8, he was transferred to the Luitpold Gymnasium (now known as the Albert Einstein Gymnasium), where he received advanced primary and secondary school education until he left Germany seven years later.

In 1894, Hermann and Jakob's company lost a bid to supply the city of Munich with electrical lighting because they lacked the capital to convert their equipment from the direct current (DC) standard to the more efficient alternating current (AC) standard. The loss forced the sale of the Munich factory. In search of business, the Einstein family moved to Italy, first to Milan and a few months later to Pavia. When the family moved to Pavia, Einstein stayed in Munich to finish his studies at the Luitpold Gymnasium. His father intended for him to pursue electrical engineering, but Einstein clashed with authorities and resented the school's regimen and teaching method. He later wrote that the spirit of learning and creative thought was lost in strict rote learning. At the end of December 1894, he travelled to Italy to join his family in Pavia, convincing the school to let him go by using a doctor's note. During his time in Italy he wrote a short essay with the title "On the Investigation of the State of the Ether in a Magnetic Field".

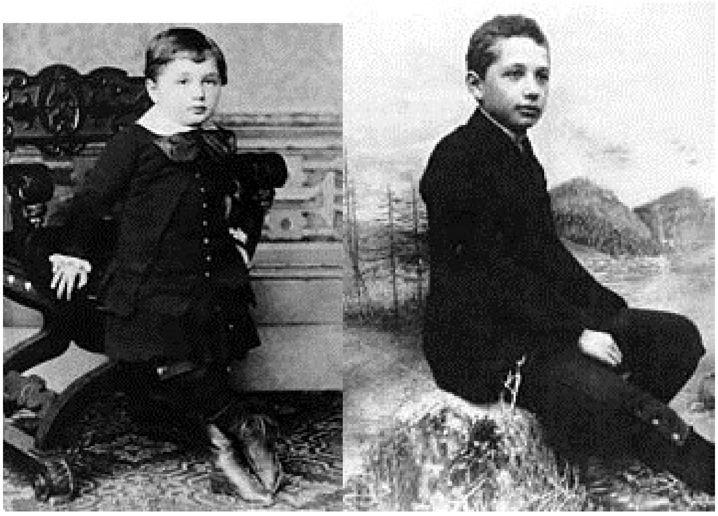


Figure 34 – Einstein at the age of 3 in 1882 and in 1893 (age 14)

Der Erziehungsrat

Albert Einstein

Figure 35 – Einstein's matriculation certificate at the age of 17, showing his final grades from the Argovian cantonal school (Aargauische Kantonsschule, on a scale of 1-6, with 6 being the highest possible mark)

In 1895, at the age of 16, Einstein sat the entrance examinations for the Swiss Federal Polytechnic in Zürich. He failed to reach the required standard in the general part of the examination, but obtained exceptional grades in physics and mathematics. On the advice of the principal of the Polytechnic, he attended the Argovian cantonal school (gymnasium) in Aarau, Switzerland, in 1895-96 to complete his secondary schooling. While lodging with the family of Professor Jost Winteler, he fell in love with Winteler's daughter, Marie. (Albert's sister Maja later married Wintelers' son Paul.) In January 1896, with his father's approval, Einstein renounced his citizenship in the German Kingdom of Württemberg to avoid military service. In September 1896, he passed the Swiss Maturawith mostly good grades, including a top grade of 6 in physics and mathematical subjects, on a scale of 1-6. Though only 17, he enrolled in the four-year mathematics and physics teaching diploma program at the Zürich Polytechnic. Marie Winteler moved to Olsberg, Switzerland, for a teaching post.

Einstein's future wife, Mileva Marić, also enrolled at the Polytechnic that year. She was the only woman among the six students in the mathematics and physics section of the teaching diploma course. Over the next few years, Einstein and Marić's friendship developed into romance, and they read books together on extra-curricular physics in which Einstein was taking an increasing interest. In 1900, Einstein was awarded the Zürich Polytechnic teaching diploma, but Marić failed the examination with a poor grade in the mathematics component, theory of functions.

Figure 36 – Albert Einstein in 1904 (age 25)

They had had a daughter, called "Lieserl" in their letters, born in early 1902 in Novi Sad where Marić was staying with her parents. Marić returned to Switzerland without the child, whose real name and fate are unknown. Einstein probably never saw his daughter.

The contents of his letter to Marić in September 1903 suggest that the girl was either adopted or died of scarlet fever in infancy.

Figure 37 – Einstein with his wife Elsa

Einstein and Marić married in January 1903. In May 1904, their first son, Hans Albert Einstein, was born in Bern, Switzerland. Their second son, Eduard, was born in Zürich in July 1910. In 1914, the couple separated; Einstein moved to Berlin and his wife remained in Zürich with their sons. They divorced on 14 February 1919, having lived apart for five years. Eduard, whom his father called "Tete" (for *petit*), had a breakdown at about age 20 and was diagnosed with schizophrenia. His mother cared for him and he was also committed to asylums for several periods, including full-time after her death.

Einstein married Elsa Löwenthal on 2 June 1919, after having had a relationship with her since 1912. She was a first cousin maternally and a second cousin paternally. In 1933, they emigrated to the United States. In 1935, Elsa Einstein was diagnosed with heart and kidney problems; she died in December 1936.

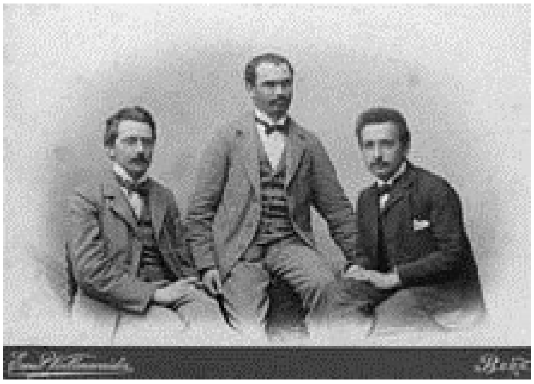


Figure 38 – Olympia Academy founders: Conrad Habicht, Maurice Solovine and Einstein

After graduating in 1900, Einstein spent almost two frustrating years searching for a teaching post. He acquired Swiss citizenship in February 1901, but was not conscripted for medical reasons. With the help of Marcel Grossmann's father, Einstein secured a job in Bern at the Federal Office for Intellectual Property, the patent office, as an assistant examiner. He evaluated patent applications for a variety of devices including a gravel sorter and an electromechanical typewriter. In 1903, Einstein's position at the Swiss Patent Office became permanent, although he was passed over for promotion until he "fully mastered machine technology".

Much of his work at the patent office related to questions about transmission of electric signals and electrical-mechanical synchronization of time, two technical problems that show up conspicuously in the thought experiments that eventually led Einstein to his radical conclusions about the nature of light and the fundamental connection between space and time.

With a few friends he had met in Bern, Einstein started a small discussion group, self-mockingly named "The Olympia Academy", which met regularly to discuss science and philosophy. Their readings included the works of Henri Poincaré, Ernst Mach, and David Hume, which influenced his scientific and philosophical outlook.

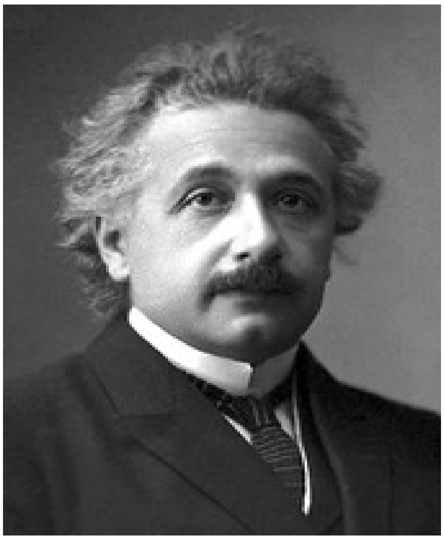


Figure 39 – Einstein's official 1921 portrait after receiving the Nobel Prize in Physics

In 1900, Einstein's paper "Conclusions from the Capillarity Phenomena" was published in the prestigious *Annalen der Physik*. On 30 April 1905, Einstein completed his thesis, with Alfred Kleiner, Professor of Experimental Physics, serving as *pro-forma* advisor. As a result, Einstein was awarded a PhD by the University of Zürich, with his dissertation entitled, "A New Determination of Molecular Dimensions." That same year, which has been called Einstein's *annus mirabilis* (miracle year), he published four groundbreaking papers, on the photoelectric effect, Brownian motion, special relativity, and the equivalence of mass and energy, which were to bring him to the notice of the academic world, at the age of 26.

By 1908, he was recognized as a leading scientist and was appointed lecturer at the University of Bern. The following year, after giving a lecture on electrodynamics and the relativity principle at the University of Zurich, Alfred Kleiner recommended him to the faculty for a newly created professorship in theoretical physics. Einstein was appointed associate professor in 1909.

Einstein became a full professor at the German Charles-Ferdinand University in Prague in April 1911, accepting Austrian citizenship in the Austro-Hungarian empire to do so. During his Prague stay Einstein wrote 11 scientific works, 5 of them on radiation mathematics and on quantum theory of the solids. In July 1912 he returned to his alma mater in Zürich. From 1912 until 1914 he was professor of theoretical physics at the ETH Zurich, where he taught analytical mechanics and thermodynamics. He also studied continuum mechanics, the molecular theory of heat, and the problem of gravitation, on which he worked with mathematician and his friend Marcel Grossmann.

In 1914, he returned to the German Empire after being appointed director of the Kaiser Wilhelm Institute for Physics (1914-1932) and a professor at the Humboldt University of Berlin, but freed from most teaching obligations. He soon became a member of the Prussian Academy of Sciences, and in 1916 was appointed president of the German Physical Society (1916-1918).

Based on calculations Einstein made in 1911, about his new theory of general relativity, light from another star would be bent by the Sun's gravity. In 1919 that prediction was confirmed by Sir Arthur Eddington during the solar eclipse of 29 May

1919. Those observations were published in the international media, making Einstein world famous. On 7 November 1919, the leading British newspaper *The Times* printed a banner headline that read: "Revolution in Science – New Theory of the Universe – Newtonian Ideas Overthrown".

In 1920, he became Foreign Member of the Royal Netherlands Academy of Arts and Sciences. In 1921, Einstein was awarded the Nobel Prize in Physics "for his services to Theoretical Physics and especially for his discovery of the law of the photoelectric effect". While General Theory of Relativity was still considered somewhat controversial, the citation also does not treat the cited work as an *explanation* but merely as a *discovery of the law*, as the idea of photons was considered outlandish and did not receive universal acceptance until the 1924 derivation of the Planck spectrum by S. N. Bose. Einstein was elected a Foreign Member of the Royal Society (ForMemRS) in 1921. He also received the Copley Medal from the Royal Society in 1925.

Figure 40 – Einstein in New York, 1921, his first visit to the United States

Einstein visited New York City for the first time on 2 April 1921, where he received an official welcome by Mayor John Francis Hylan, followed by three weeks of lectures and receptions. He went on to deliver several lectures at Columbia University and Princeton University, and in Washington he accompanied representatives of the National Academy of Science on a visit to the White House. On his return to Europe he was the guest of the British statesman and philosopher Viscount Haldane in London, where he met several renowned scientific, intellectual and political figures, and delivered a lecture at King's College London.

He also published an essay, "My First Impression of the U.S.A.," in July 1921, in which he tried briefly to describe some characteristics of Americans, much as had Alexis de Tocqueville, who published his own impressions in *Democracy in America* (1835). For some of his observations, Einstein was clearly surprised: "What strikes a visitor is the joyous, positive attitude to life. The American is friendly, self-confident, optimistic, and without envy."

In 1922, his travels took him to Asia and later to Palestine, as part of a six-month excursion and speaking tour, as he visited Singapore, Ceylon and Japan, where he gave a series of lectures to thousands of Japanese. After his first public lecture, he met the emperor and empress at the Imperial Palace, where thousands came to watch. In a letter to his sons, Einstein described his impression of the Japanese as being modest, intelligent, considerate, and having a true feel for art.

Because of Einstein's travels to the Far East, he was unable to personally accept the Nobel Prize for Physics at the Stockholm award ceremony in December 1922. In his place, the banquet speech was held by a German diplomat, who praised Einstein not only as a scientist but also as an international peacemaker and activist.

On his return voyage, he visited Palestine for 12 days in what would become his only visit to that region. Einstein was greeted as if he were a head of state, rather than a physicist, which included a cannon salute upon arriving at the home of the British high commissioner, Sir Herbert Samuel. During one reception, the building was stormed by people who wanted to see and hear him. In Einstein's talk to the audience, he expressed happiness that the Jewish people were beginning to be recognized as a force in the world.

In December 1930, Einstein visited America for the second time, originally intended as a two-month working visit as a research fellow at the California Institute of Technology. After the national attention he received during his first trip to the U.S., he and his arrangers aimed to protect his privacy.

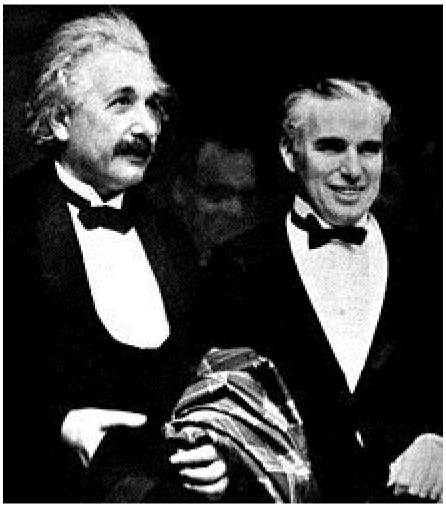


Figure 41 – Charlie Chaplin and Einstein at the Hollywood premier of City Lights, January 1931

Einstein next traveled to California where he met Caltech president and Nobel laureate, Robert A. Millikan. His friendship with Millikan was "awkward", as Millikan "had a penchant for patriotic militarism," where Einstein was a pronounced pacifist. During an address to Caltech's students, Einstein noted that science was often inclined to do more harm than good.

This aversion to war also led Einstein to befriend author Upton Sinclair and film star Charlie Chaplin, both noted for their pacifism. Carl Laemmle, head of Universal Studios, gave Einstein a tour of his studio and introduced him to Chaplin. They had an instant rapport, with Chaplin inviting Einstein and his wife, Elsa, to his home for dinner. Chaplin said Einstein's outward persona, calm and gentle, seemed to conceal a "highly emotional temperament," from which came his "extraordinary intellectual energy."

Chaplin also remembers Elsa telling him about the time Einstein conceived his theory of relativity. During breakfast one morning, he seemed lost in thought and ignored his food. She asked him if something was bothering him. He sat down at his piano and started playing. He continued playing and writing notes for half an hour, then went upstairs to his study, where he remained for two weeks, with Elsa bringing up his food. At the end of the two weeks he came downstairs with two sheets of paper bearing his theory.

Chaplin's film, *City Lights*, was to premier a few days later in Hollywood, and Chaplin invited Einstein and Elsa to join him as his special guests. Walter Isaacson, Einstein's biographer, described this as "one of the most memorable scenes in the new era of celebrity." Einstein and Chaplin arrived together, in black tie, with Elsa joining them, "beaming." The audience applauded as they entered the theater. Chaplin visited Einstein at his home on a later trip to Berlin, and recalled his "modest little flat" and the piano at which he had begun writing his theory. Chaplin speculated that it was "possibly used as kindling wood by the Nazis".

In February 1933 while on a visit to the United States, Einstein knew he could not return to Germany with the rise to power of the Nazisunder Germany's new chancellor, Adolf Hitler.

While at American universities in early 1933, he undertook his third two-month visiting professorship at the California Institute of Technology in Pasadena. He and his wife Elsa returned to Belgium by ship in March, and during the trip they learned that their cottage was raided by the Nazis and his personal sailboat confiscated. Upon landing in Antwerp on 28 March, he immediately went to the German consulate and turned in his passport, formally renouncing his German citizenship. A few years later, the Nazis sold his boat and turned his cottage into a Hitler Youth camp.

In April 1933, Einstein discovered that the new German government had passed laws barring Jews from holding any official positions, including teaching at universities. A month later, Einstein's works were among those targeted by Nazi book burnings, with Nazi propaganda minister Joseph Goebbels proclaiming, "Jewish intellectualism is dead." One German magazine included him in a list of enemies of the German regime with the phrase, "not yet hanged", offering a $5,000 bounty on his head.

Figure 42 – Cartoon of Einstein, who has shed his "Pacifism" wings, standing next to a pillar labeled "World Peace." He is rolling up his sleeves and holding a sword labelled "Preparedness" (by Charles R. Macauley, 1933)

Einstein was now without a permanent home, unsure where he would live and work, and equally worried about the fate of countless other scientists still in Germany. He rented a house in De Haan, Belgium, where he lived for a few months. In late July 1933, he went to England for about six weeks at the personal invitation of British naval officer Commander Oliver Locker-Lampson, who had become friends with Einstein in the preceding years. To protect Einstein, Locker-Lampson had two assistants watch over him at his secluded cottage outside London, with the press publishing a photo of them guarding Einstein.

Figure 43 – Einstein surrounded by Oliver Locker-Lampson (seated) and assistants assigned to protect him

Locker-Lampson took Einstein to meet Winston Churchill at his home, and later, Austen Chamberlain and former Prime Minister Lloyd George. Einstein asked them to help bring Jewish scientists out of Germany. British historian Martin Gilbert notes that Churchill responded immediately, and sent his friend, physicist Frederick Lindemann to Germany to seek out Jewish scientists and place them in British universities. Churchill later observed that as a result of Germany having driven the Jews out, they had lowered their "technical standards" and put the Allies' technology ahead of theirs.

Einstein later contacted leaders of other nations, including Turkey's Prime Minister, İsmet İnönü, to whom he wrote in September 1933 requesting placement of unemployed German-Jewish scientists. As a result of Einstein's letter, Jewish invitees to Turkey eventually totaled over "1,000 saved individuals."

Locker-Lampson also submitted a bill to parliament to extend British citizenship to Einstein, during which period Einstein made a number of public appearances describing the crisis brewing in Europe. The bill failed to become law, however, and Einstein then accepted an earlier offer from the Princeton Institute for Advanced Study, in the U.S., to become a resident scholar.

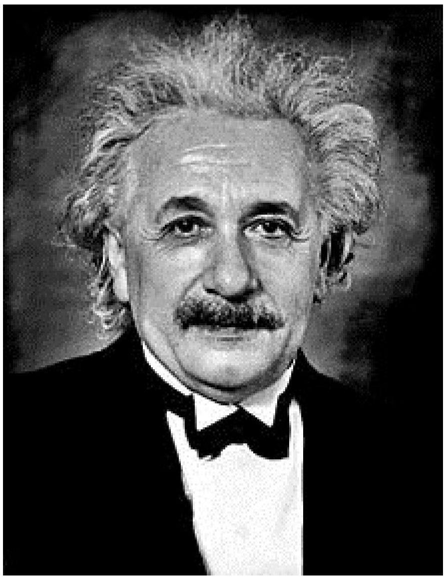


Figure 44 – Portrait taken in 1935 in Princeton

In October 1933 Einstein returned to the U.S. and took up a position at the Institute for Advanced Study (in Princeton, New Jersey), noted for having become a refuge for scientists fleeing Nazi Germany. At the time, most American universities, including

Harvard, Princeton and Yale, had minimal or no Jewish faculty or students, as a result of their Jewish quota which lasted until the late 1940s.

Einstein was still undecided on his future. He had offers from several European universities, including Christ Church, Oxford where he stayed for three short periods between May 1931 and June 1933 and was offered a 5 year Studentship, but in 1935 he arrived at the decision to remain permanently in the United States and apply for citizenship.

Einstein's affiliation with the Institute for Advanced Study would last until his death in 1955. He was one of the four first selected (two of the others being John von Neumann and Kurt Gödel) at the new Institute, where he soon developed a close friendship with Gödel. The two would take long walks together discussing their work. Bruria Kaufman, his assistant, later became a physicist. During this period, Einstein tried to develop a unified field theory and to refute the accepted interpretation of quantum physics, both unsuccessfully.

In 1939, a group of Hungarian scientists that included émigré physicist Leó Szilárd attempted to alert Washington to ongoing Nazi atomic bomb research. The group's warnings were discounted. Einstein and Szilárd, along with other refugees such as Edward Teller and Eugene Wigner, "regarded it as their responsibility to alert Americans to the possibility that German scientists might win the race to build an atomic bomb, and to warn that Hitler would be more than willing to resort to such a weapon." To make certain the U.S. was aware of the danger, in July 1939, a few months before the beginning of World War II in Europe, Szilárd and Wigner visited Einstein to explain the possibility of atomic bombs, which Einstein, a pacifist, said he had never considered. He was asked to lend his support by writing a letter, with Szilárd, to President Roosevelt, recommending the U.S. pay attention and engage in its own nuclear weapons research. A secret German facility, apparently the largest of the Third Reich, covering 75 acres in an underground complex, was being re-excavated in Austria in December 2014 and may have been planned for use in nuclear research and development.

The letter is believed to be "arguably the key stimulus for the U.S. adoption of serious investigations into nuclear weapons on the eve of the U.S. entry into World War

II". In addition to the letter, Einstein used his connections with the Belgian Royal Family and the Belgian queen mother to get access with a personal envoy to the White House's Oval Office. President Roosevelt could not take the risk of allowing Hitler to possess atomic bombs first. As a result of Einstein's letter and his meetings with Roosevelt, the U.S. entered the "race" to develop the bomb, drawing on its "immense material, financial, and scientific resources" to initiate the Manhattan Project. It became the only country to successfully develop an atomic bomb during World War II.

Einstein became an American citizen in 1940. Not long after settling into his career at the Institute for Advanced Study (in Princeton, New Jersey), he expressed his appreciation of the meritocracy in American culture when compared to Europe. He recognized the "right of individuals to say and think what they pleased", without social barriers, and as a result, individuals were encouraged, he said, to be more creative, a trait he valued from his own early education.

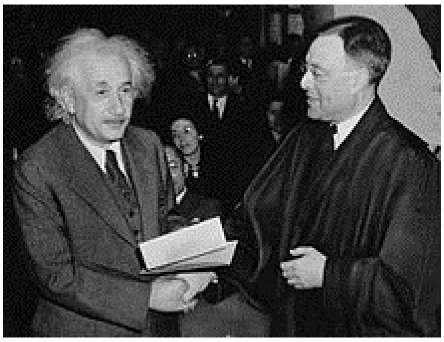


Figure 45 – Einstein accepting U.S. citizenship certificate from judge Phillip Forman

On 17 April 1955, Albert Einstein experienced internal bleeding caused by the rupture of an abdominal aortic aneurysm, which had previously been reinforced surgically by Rudolph Nissen in 1948. He took the draft of a speech he was preparing for a television appearance commemorating the State of Israel's seventh anniversary with him to the hospital, but he did not live long enough to complete it.

Einstein refused surgery, saying: "I want to go when I want. It is tasteless to prolong life artificially. I have done my share, it is time to go. I will do it elegantly." He died in

Princeton Hospital early the next morning at the age of 76, having continued to work until near the end.

During the autopsy, the pathologist of Princeton Hospital, Thomas Stoltz Harvey, removed Einstein's brain for preservation without the permission of his family, in the hope that the neuroscience of the future would be able to discover what made Einstein so intelligent. Einstein's remains were cremated and his ashes were scattered at an undisclosed location.

In his lecture at Einstein's memorial, nuclear physicist Robert Oppenheimer summarized his impression of him as a person: "He was almost wholly without sophistication and wholly without worldliness. There was always with him a wonderful purity at once childlike and profoundly stubborn".

Throughout his life, Einstein published hundreds of books and articles. He published more than 300 scientific papers and 150 non-scientific ones. On 5 December 2014, universities and archives announced the release of Einstein's papers, comprising more than 30,000 unique documents. Einstein's intellectual achievements and originality have made the word "Einstein" synonymous with "genius". In addition to the work he did by himself he also collaborated with other scientists on additional projects including the Bose–Einstein statistics, the Einstein refrigerator and others.

Albert Einstein's first paper submitted in 1900 to *Annalen der Physik* was on capillary attraction. It was published in 1901 with the title "Folgerungen aus den Capillaritätserscheinungen", which translates as "Conclusions from the capillarity phenomena". Two papers he published in 1902-1903 (thermodynamics) attempted to interpretatomic phenomena from a statistical point of view. These papers were the foundation for the 1905 paper on Brownian motion, which showed that Brownian movement can be construed as firm evidence that molecules exist. His research in 1903 and 1904 was mainly concerned with the effect of finite atomic size on diffusion phenomena.

He articulated the principle of relativity. This was understood by Hermann Minkowski to be a generalization of rotational invariance from space to space-time. Other principles postulated by Einstein and later vindicated are the principle of equivalence and the principle of adiabatic invariance of the quantum number.

The *Annus Mirabilis* papers are four articles pertaining to the photoelectric effect (which gave rise to quantum theory), Brownian motion, the special theory of relativity, and $E = mc^2$ that Albert Einstein published in the *Annalen der Physik* scientific journal in 1905. These four works contributed substantially to the foundation of modern physics and changed views on space, time, and matter. The four papers are table 1:

Einstein's "*Zur Elektrodynamik bewegter Körper*" ("On the Electrodynamics of Moving Bodies") was received on 30 June 1905 and published 26 September of that same year. It reconciles Maxwell's equations for electricity and magnetism with the laws of mechanics, by introducing major changes to mechanics close to the speed of light. This later became known as Einstein's special theory of relativity.

Consequences of this include the time-space frame of a moving body appearing to slow down and contract (in the direction of motion) when measured in the frame of the observer. This paper also argued that the idea of a luminiferous aether—one of the leading theoretical entities in physics at the time—was superfluous.

Table 1 – Four works contributed to the foundation of modern physics

Title (translated)	Area of focus	Received	Published	Significance
On a Heuristic Viewpoint Concerning the Production and Transformation of Light	Photoelectric effect	18 March	9 June	Resolved an unsolved puzzle by suggesting that energy is exchanged only in discrete amounts (quanta). This idea was pivotal to the early development of quantum theory.
On the Motion of Small Particles Suspended in a Stationary Liquid, as Required by the Molecular Kinetic Theory of Heat	Brownian motion	11 May	18 July	Explained empirical evidence for the atomic theory, supporting the application of statistical physics.

On the Electrodynamics of Moving Bodies	Special relativity	30 June	26 September	Reconciled Maxwell's equations for electricity and magnetism with the laws of mechanics by introducing major changes to mechanics close to the speed of light, resulting from analysis based on empirical evidence that the speed of light is independent of the motion of the observer. Discredited the concept of a "luminiferous either."
Does the Inertia of a Body Depend Upon Its Energy Content?	Matter–energy equivalence	27 September	21 November	Equivalence of matter and energy, E = mc2 (and by implication, the ability of gravity to "bend" light), the existence of "rest energy", and the basis of nuclear energy.

In his paper on mass–energy equivalence, Einstein produced $E = mc^2$ from his special relativity equations. Einstein's 1905 work on relativity remained controversial for many years, but was accepted by leading physicists, starting with Max Planck.

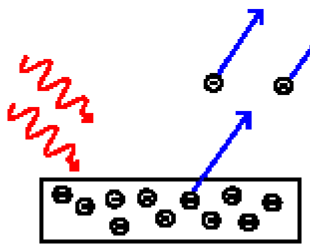


Figure 46 – The photoelectric effect. Incoming photons on the left strike a metal plate (bottom) and eject electrons, depicted as flying off to the right

In a 1905 paper, Einstein postulated that light itself consists of localized particles (*quanta*). Einstein's light quanta were nearly universally rejected by all physicists, including Max Planck and Niels Bohr. This idea only became universally accepted in 1919, with Robert Millikan's detailed experiments on the photoelectric effect, and with the measurement of Compton scattering.

Einstein concluded that each wave of frequency f is associated with a collection of photons with energy hf each, where h is Planck's constant. He does not say much more, because he is not sure how the particles are related to the wave. But he does suggest that this idea would explain certain experimental results, notably the photoelectric effect.

In 1907, Einstein proposed a model of matter where each atom in a lattice structure is an independent harmonic oscillator. In the Einstein model, each atom oscillates independently–a series of equally spaced quantized states for each oscillator. Einstein was aware that getting the frequency of the actual oscillations would be different, but he nevertheless proposed this theory because it was a particularly clear demonstration that quantum mechanics could solve the specific heat problem in classical mechanics. Peter Debye refined this model.

Throughout the 1910s, quantum mechanics expanded in scope to cover many different systems. After Ernest Rutherford discovered the nucleus and proposed that electrons orbit like planets, Niels Bohr was able to show that the same quantum mechanical postulates introduced by Planck and developed by Einstein would explain the discrete motion of electrons in atoms, and the periodic table of the elements.

Einstein contributed to these developments by linking them with the 1898 arguments Wilhelm Wien had made. Wien had shown that the hypothesis of adiabatic invariance of a thermal equilibrium state allows all the blackbody curves at different temperature to be derived from one another by a simple shifting process. Einstein noted in 1911 that the same adiabatic principle shows that the quantity which is quantized in any mechanical motion must be an adiabatic invariant. Arnold Sommerfeld identified this adiabatic invariant as the action variable of classical mechanics.

Although the patent office promoted Einstein to Technical Examiner Second Class in 1906, he had not given up on academia. In 1908, he became a *Privatdozent* at the University of Bern. In "*über die Entwicklung unserer Anschauungen über das Wesen und die Konstitution der Strahlung*" ("The Development of our Views on the Composition and Essence of Radiation"), on the quantization of light, and in an earlier 1909 paper, Einstein showed that Max Planck's energy quanta must have well-defined momenta and act in some respects as independent, point-like particles. This paper introduced the *photon* concept (although the name *photon* was introduced later by Gilbert N. Lewis in 1926) and inspired the notion of wave–particle duality in quantum mechanics. Einstein saw this wave-particle duality in radiation as concrete evidence for his conviction that physics needed a new, unified foundation.

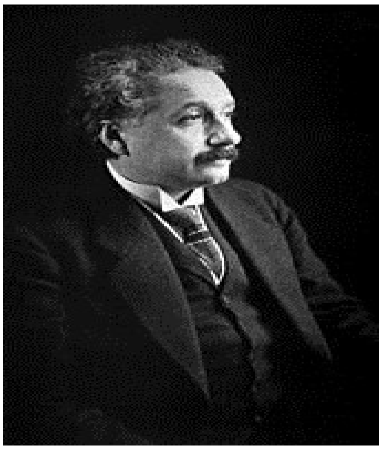


Figure 47 – Einstein during his visit to the United States

Theory of critical opalescence

Einstein returned to the problem of thermodynamic fluctuations, giving a treatment of the density variations in a fluid at its critical point. Ordinarily the density fluctuations are controlled by the second derivative of the free energy with respect to the density. At the critical point, this derivative is zero, leading to large fluctuations. The effect of density fluctuations is that light of all wavelengths is scattered, making the fluid look milky white. Einstein relates this to Rayleigh scattering which is what happens when the fluctuation size is much smaller than the wavelength, and which explains why the sky is blue.[138] Einstein quantitatively derived critical opalescence from a treatment of density fluctuations, and demonstrated how both the effect and Rayleigh scattering originate from the atomistic constitution of matter.

Zero-point energy

In a series of works completed from 1911 to 1913, Planck reformulated his 1900 quantum theory and introduced the idea of zero-point energy in his "second quantum theory." Soon, this idea attracted the attention of Albert Einstein and his assistant Otto Stern. Assuming the energy of rotating diatomic molecules contains zero-point energy, they then compared the theoretical specific heat of hydrogen gas with the experimental data. The numbers matched nicely. However, after publishing the findings, they promptly withdrew their support, because they no longer had confidence in the correctness of the idea of zero-point energy.

General relativity and the equivalence principle

General relativity (GR) is a theory of gravitation that was developed by Albert Einstein between 1907 and 1915. According to general relativity, the observed gravitational attraction between masses results from the warping of space and time by those masses. General relativity has developed into an essential tool in modern astrophysics. It provides the foundation for the current understanding of black holes, regions of space where gravitational attraction is so strong that not even light can escape.

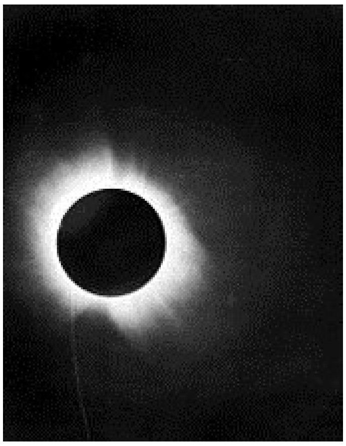


Figure 48 – Eddington's photograph of a solar eclipse

As Albert Einstein later said, the reason for the development of general relativity was that the preference of inertial motions within special relativity was unsatisfactory, while a theory which from the outset prefers no state of motion (even accelerated ones) should appear more satisfactory. Consequently, in 1907 he published an article on acceleration under special relativity. In that article titled "On the Relativity Principle and the Conclusions Drawn from It", he argued that free fall is really inertial motion and that for a free-falling observer the rules of special relativity must apply. This argument is called the equivalence principle. In the same article, Einstein also predicted the phenomena of gravitational time dilation, gravitational red shift and deflection of light.

In 1911, Einstein published another article "On the Influence of Gravitation on the Propagation of Light" expanding on the 1907 article, in which he estimated the amount of deflection of light by massive bodies. Thus, the theoretical prediction of general relativity can for the first time be tested experimentally.

Gravitational waves

In 1916, Einstein predicted gravitational waves, ripples in the curvature of space time which propagate as waves, traveling outward from the source, transporting energy as gravitational radiation. The existence of gravitational waves is possible under general relativity due to its Lorentz invariance which brings the concept of a finite speed of propagation of the physical interactions of gravity with it. By contrast, gravitational waves cannot exist in the Newtonian theory of gravitation, which postulates that the physical interactions of gravity propagate at infinite speed.

The first, indirect, detection of gravitational waves came in the 1970s through observation of a pair of closely orbiting neutron stars, PSR B1913+16. The explanation of the decay in their orbital period was that they were emitting gravitational waves. Einstein's prediction was confirmed on 11 February 2016, when researchers at LIGO published direct observation, on Earth, of gravitational waves, exactly one hundred years after the prediction.

Hole argument and Entwurf theory

While developing general relativity, Einstein became confused about the gauge invariance in the theory. He formulated an argument that led him to conclude that a general relativistic field theory is impossible. He gave up looking for fully generally covariant tensor equations, and searched for equations that would be invariant under general linear transformations only.

In June 1913, the Entwurf ("draft") theory was the result of these investigations. As its name suggests, it was a sketch of a theory, less elegant and more difficult than general relativity, with the equations of motion supplemented by additional gauge fixing conditions. After more than two years of intensive work, Einstein realized that the hole argumentwas mistaken and abandoned the theory in November 1915.

Cosmology

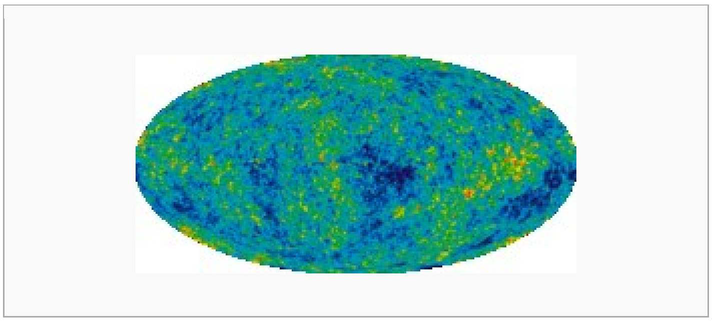


Figure 49 – Big Bang

In 1917, Einstein applied the general theory of relativity to the structure of the universe as a whole. He discovered that the general field equations predicted a universe that was dynamic, either contracting or expanding. As observational evidence for a dynamic universe was not known at the time, Einstein introduced a new term, the cosmological constant, to the field equations, in order to allow the theory to predict a static universe. The modified field equations predicted a static universe of closed curvature, in accordance with Einstein's understanding of Mach's principle in these years.

Following the discovery of the recession of the nebulae by Edwin Hubble in 1929, Einstein abandoned his static model of the universe, and proposed two dynamic models of the cosmos, the Friedman-Einstein model of 1931 and the Einstein-deSitter model of 1932. In each of these models, Einstein discarded the cosmological constant, claiming that it was "in any case theoretically unsatisfactory".

In many Einstein biographies, it is claimed that Einstein referred to the cosmological constant in later years as his "biggest blunder". The astrophysicist Mario Livio has recently cast doubt on this claim, suggesting that it may be exaggerated.

In late 2013, a team led by the Irish physicist Cormac O'Raifeartaigh discovered evidence that, shortly after learning of Hubble's observations of the recession of the nebulae, Einstein considered a steady-state model of the universe. In a hitherto overlooked manuscript, apparently written in early 1931, Einstein explored a model of the expanding universe in which the density of matter remains constant due to a continuous creation of matter, a process he associated with the cosmological constant. As he stated in the paper, "In what follows, I would like to draw attention to a solution to equation (1) that can account for Hubbel's sic facts, and in which the density is constant over time"..."If one considers a physically bounded volume, particles of matter will be continually leaving it. For the density to remain constant, new particles of matter must be continually formed in the volume from space."

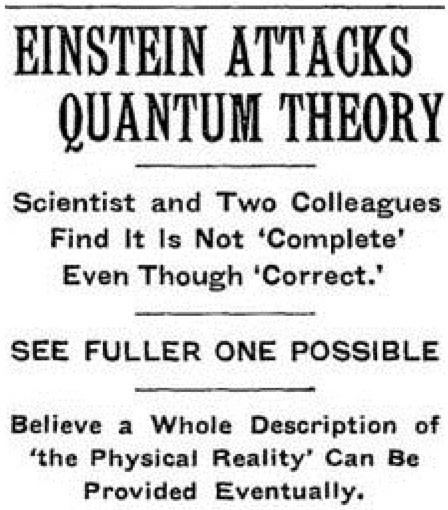
It thus appears that Einstein considered a Steady State model of the expanding universe many years before Hoyle, Bondi and Gold. However, Einstein's steady-state model contained a fundamental flaw and he quickly abandoned the idea.

Modern quantum theory

Einstein was displeased with quantum theory and quantum mechanics (the very theory he helped create), despite its acceptance by other physicists, stating that God "is not playing at dice." Einstein continued to maintain his disbelief in the theory, and attempted unsuccessfully to disprove it until he died at the age of 76. In 1917, at the height of his work on relativity, Einstein published an article in *Physikalische Zeitschrift* that proposed the possibility of stimulated emission, the physical process that makes possible the maser and the laser. This article showed that the statistics of absorption and emission of light would only be consistent with Planck's distribution law if the emission of light into a mode with n photons would be enhanced statistically compared to the emission of light into an empty mode. This paper was enormously influential in the later development of quantum mechanics, because it was the first paper to show that the statistics of atomic transitions had simple laws. Einstein discovered Louis de Broglie's work, and supported his ideas, which were received skeptically at first. In another major paper from this era, Einstein gave a wave equation for de Broglie waves, which Einstein suggested was the Hamilton–Jacobi equation of mechanics. This paper would inspire Schrödinger's work of 1926.

Bose–Einstein statistics

In 1924, Einstein received a description of a statistical model from Indian physicist Satyendra Nath Bose, based on a counting method that assumed that light could be understood as a gas of indistinguishable particles. Einstein noted that Bose's statistics applied to some atoms as well as to the proposed light particles, and submitted his translation of Bose's paper to the *Zeitschrift für Physik*. Einstein also published his own articles describing the model and its implications, among them the Bose–Einstein condensate phenomenon that some particulates should appear at very low temperatures. It was not until 1995 that the first such condensate was produced experimentally by Eric Allin Cornell and Carl Wieman using ultra-cooling equipment built at the NIST–JILA laboratory at the University of Colorado at Boulder. Bose–Einstein statistics are now used to describe the behaviors of any assembly of bosons. Einstein's sketches for this project may be seen in the Einstein Archive in the library of the Leiden University.


EINSTEIN ATTACKS QUANTUM THEORY

Scientist and Two Colleagues Find It Is Not 'Complete' Even Though 'Correct.'

SEE FULLER ONE POSSIBLE

Believe a Whole Description of 'the Physical Reality' Can Be Provided Eventually.

Figure 50 – Newspaper headline on May 4, 1935

Energy momentum pseudotensor

General relativity includes a dynamical spacetime, so it is difficult to see how to identify the conserved energy and momentum. Noether's theorem allows these quantities to be determined from a Lagrangian with translation invariance, but general covariance makes translation invariance into something of a gauge symmetry. The energy and momentum derived within general relativity by Noether's presecriptions do not make a real tensor for this reason.

Einstein argued that this is true for fundamental reasons, because the gravitational field could be made to vanish by a choice of coordinates. He maintained that the non-covariant energy momentum pseudotensor was in fact the best description of the energy momentum distribution in a gravitational field. This approach has been echoed by Lev Landau and Evgeny Lifshitz, and others, and has become standard.

The use of non-covariant objects like pseudotensors was heavily criticized in 1917 by Erwin Schrödinger and others.

Unified field theory

Following his research on general relativity, Einstein entered into a series of attempts to generalize his geometric theory of gravitation to include electromagnetism as another aspect of a single entity. In 1950, he described his "unified field theory" in a *Scientific American* article entitled "On the Generalized Theory of Gravitation". Although he continued to be lauded for his work, Einstein became increasingly isolated in his research, and his efforts were ultimately unsuccessful. In his pursuit of a unification of the fundamental forces, Einstein ignored some mainstream developments in physics, most notably the strong and weak nuclear forces, which were not well understood until many years after his death. Mainstream physics, in turn, largely ignored Einstein's approaches to unification. Einstein's dream of unifying other laws of physics with gravity motivates modern quests for a theory of everything and in particular string theory, where geometrical fields emerge in a unified quantum-mechanical setting.

Wormholes

Einstein collaborated with others to produce a model of a wormhole. His motivation was to model elementary particles with charge as a solution of gravitational field equations, in line with the program outlined in the paper "Do Gravitational Fields play an Important Role in the Constitution of the Elementary Particles? These solutions cut and pasted Schwarzschild black holes to make a bridge between two patches.

If one end of a wormhole was positively charged, the other end would be negatively charged. These properties led Einstein to believe that pairs of particles and antiparticles could be described in this way.

Einstein–Cartan theory

In order to incorporate spinning point particles into general relativity, the affine connection needed to be generalized to include an antisymmetric part, called the torsion. This modification was made by Einstein and Cartan in the 1920s.

Equations of motion

The theory of general relativity has a fundamental law—the Einstein equations which describe how space curves, the geodesic equation which describes how particles move may be derived from the Einstein equations.

Since the equations of general relativity are non-linear, a lump of energy made out of pure gravitational fields, like a black hole, would move on a trajectory which is determined by the Einstein equations themselves, not by a new law. So Einstein proposed that the path of a singular solution, like a black hole, would be determined to be a geodesic from general relativity itself.

This was established by Einstein, Infeld, and Hoffmann for point-like objects without angular momentum, and by Roy Kerr for spinning objects.

Einstein conducted other investigations that were unsuccessful and abandoned. These pertain to force, superconductivity, gravitational waves, and other research.

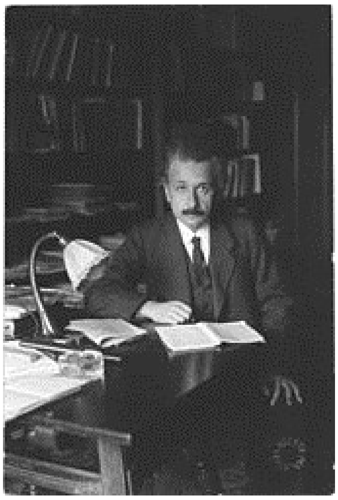


Figure 51 – Einstein at his office, University of Berlin, 1920

Collaboration with other scientists

In addition to longtime collaborators Leopold Infeld, Nathan Rosen, Peter Bergmann and others, Einstein also had some one-shot collaborations with various scientists.

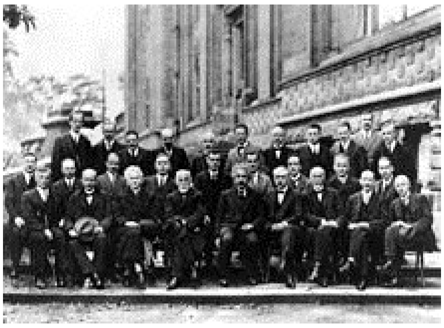


Figure 52 – The 1927 Solvay Conference in Brussels, a gathering of the world's top physicists. Einstein in the center

Einstein–de Haas experiment

Einstein and De Haas demonstrated that magnetization is due to the motion of electrons, nowadays known to be the spin. In order to show this, they reversed the magnetization in an iron bar suspended on a torsion pendulum. They confirmed that this leads the bar to rotate, because the electron's angular momentum changes as the magnetization changes. This experiment needed to be sensitive, because the angular momentum associated with electrons is small, but it definitively established that electron motion of some kind is responsible for magnetization.

Schrödinger gas model

Einstein suggested to Erwin Schrödinger that he might be able to reproduce the statistics of a Bose–Einstein gas by considering a box. Then to each possible quantum motion of a particle in a box associate an independent harmonic oscillator. Quantizing these oscillators, each level will have an integer occupation number, which will be the number of particles in it.

This formulation is a form of second quantization, but it predates modern quantum mechanics. Erwin Schrödinger applied this to derive the thermodynamic properties of asemi-classical ideal gas. Schrödinger urged Einstein to add his name as co-author, although Einstein declined the invitation.

Einstein refrigerator

In 1926, Einstein and his former student Leó Szilárd co-invented (and in 1930, patented) the Einstein refrigerator. This absorption refrigerator was then revolutionary for having no moving parts and using only heat as an input. On 11 November 1930, U.S. Patent 1,781,541 was awarded to Albert Einstein and Leó Szilárd for the refrigerator. Their invention was not immediately put into commercial production, and the most promising of their patents were acquired by the Swedish company Electrolux.

Bohr versus Einstein

The Bohr–Einstein debates were a series of public disputes about quantum mechanics between Albert Einstein and Niels Bohr who were two of its founders. Their debates are remembered because of their importance to the philosophy of science. Their debates would influence later interpretations of quantum mechanics.

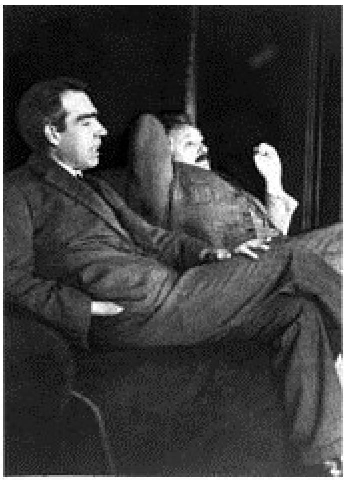


Figure 53 – Einstein and Niels Bohr, 1925

Einstein–Podolsky–Rosen paradox

In 1935, Einstein returned to the question of quantum mechanics. He considered how a measurement on one of two entangled particles would affect the other. He noted, along with his collaborators, that by performing different measurements on the distant particle, either of position or momentum, different properties of the entangled partner could be discovered without disturbing it in any way.

He then used a hypothesis of local realism to conclude that the other particle had these properties already determined. The principle he proposed is that if it is possible to determine what the answer to a position or momentum measurement would be, without in any way disturbing the particle, then the particle actually has values of position or momentum.

This principle distilled the essence of Einstein's objection to quantum mechanics. As a physical principle, it was shown to be incorrect when the Aspect experiment of 1982 confirmed Bell's theorem, which had been promulgated in 1964.

Einstein received numerous awards and honors, including the Nobel Prize in Physics.

6.1.2 Find the meaning of the words in the dictionary and learn them:

physicist; equivalence formula; partical theory; thermal properties of light; research; nuclear fission; direct current; alternating current; extra-curricular physics; molecular dimensions; solids; calculations; solar eclipse; nuclear weapon; cappilar attraction; density fluctuations; wormhole.

6.1.3 Draw a table of the main Einstein’s discoveries.

6.1.4 What position do you think would Einstein apply currently. Write his CV.

6.2 Sofia Kovalevskaya

6.2.1 Read and translate text B:

Sofia Vasilyevna Kovalevskaya (Fig. 53) born Sofia Vasilyevna Korvin-Krukovskaya (1850-1891), was the first major Russian female mathematician and responsible for important original contributions to analysis, partial differential equations and mechanics. She was the first woman appointed to a full professorship in Northern Europe and was also one of the first women to work for a scientific journal as an editor. Her sister was the socialist and feminist Anne Jaclard.

There are several alternative transliterations of her name. She herself used Sophie Kowalevski (or occasionally Kowalevsky), for her academic publications. After moving to Sweden, she called herself Sonya.

Sofia Kovalevskaya was born in Moscow, the second of three children. Her father, Lieutenant General Vasily Vasilyevich Korvin-Krukovsky, served in the Imperial Russian Army as head of the Moscow Artillery before retiring to Palibino his family estate in Vitebsk province in 1858, when Sophie was eight years old. He was a member of the minor nobility, of mixed Russian - Polish descent (Polish on his father's side), with possible partial ancestry from the Royal Korvin family of Hungary, and served as Marshall of Nobility for Vitebsk province. (There may also have been some Romani ancestry on the father's side.)

Figure 53 – Sofia Kovalevskaya in 1880

Her mother, Yelizaveta Fedorovna Shubert, descended from a family of German immigrants to St. Petersburg, who lived on Vasilievsky Island. Her maternal great grandfather was the astronomer and geographer Friedrich Theodor Schubert (1758-1825), who emigrated to Russia from Germany around 1785. He became full member of the St. Petersburg Academy of Science and head of its astronomical observatory. His son, Sophie's maternal grandfather, was General Theodor Friedrich von Schubert (Shubert)

(1789-1865), who was head of the military topographic service, and honorary member of the Russian Academy of Sciences, as well as Director of the Kunstkamera museum.

Her parents provided her with a good early education through a private Polish tutor Y.I. Malevich. When she was 11 years old, she was intrigued by an unusual premonition of what she was to learn later in her lessons in calculus; the wall of her room had been papered with pages from lecture notes by Ostrogradsky, left over from her father's student days. After she displayed an unusual, original flair for mathematics, she was provided with a tutor in St. Petersburg (A. N. Strannoliubskii, a well-known advocate of higher education for women), who taught her calculus. During that same period, the son of the local priest introduced her sister Anna to progressive ideas influenced by the "Movement of the 1860's", providing her with copies of radical journals of the time discussing nihilism.

Despite her obvious talent for mathematics, she could not complete her education in Russia. At that time, women there were not allowed to attend universities. In order to study abroad, she needed written permission from her father (or husband). Accordingly, she contracted a "fictitious marriage" with Vladimir Kovalevskij, then a young paleontology student who would later become famous for his collaboration with Charles Darwin. They emigrated from Russia in 1867.

Student years

In 1869, Kovalevskaya began attending the University of Heidelberg, Germany, which allowed her to audit classes as long as the professors involved gave their approval.

Shortly after beginning her studies there, she visited London with Vladimir, who spent time with his colleagues Thomas Huxley and Charles Darwin, while she was invited to attend George Eliot's Sunday salons. There, at age nineteen, she met Herbert Spencer and was led into a debate, at Eliot's instigation, on "woman's capacity for abstract thought". This was well before she made her notable contribution of the "Kovalevskaya top" to the brief list of known examples of integrable rigid body motion (see following section). George Eliot was writing *Middlemarch* at the time, in which one finds the remarkable sentence: "In short, woman was a problem which, since Mr. Brooke's mind felt blank before it, could hardly be less complicated than the revolutions of an irregular solid". Kovalevskaya participated in social movements and shared ideas of utopian socialism. In 1871 she traveled to Paris together with her husband in order to attend to the injured from the Paris Commune. Kovalevskaya helped save Victor Jaclard, who was the husband of her sister Ann (Anne Jaclard).

After two years of mathematical studies at Heidelberg under such teachers as Hermann von Helmholtz, Gustav Kirchhoff and Robert Bunsen, she moved to Berlin, where she had to take private lessons from Karl Weierstrass, as the university would not even allow her to audit classes. In 1874 she presented three papers-on partial differential equations, on the dynamics of Saturn's rings and on elliptic integrals-to the University of Göttingen as her doctoral dissertation. With the support of Weierstrass, this earned her a doctorate in mathematics *summa cum laude*, bypassing the usual required lectures and examinations.

She thereby became the first woman in Europe to hold that degree. Her paper on partial differential equations contains what is now commonly known as the Cauchy-Kovalevskaya theorem, which gives conditions for the existence of solutions to a certain class of those equations.

Last years in Germany and Sweden

Figure 54 – Bust by Finnish sculptor Walter Runeberg

In the early 1880s, Sofia and her husband Vladimir developed financial problems. Sofia wanted to be a lecturer at the university; however, she was not allowed to because she was a woman, despite volunteering to provide free lectures. Soon after, Vladimir started a house building business with Sofia as his assistant. In 1879, the price for mortgages became higher and they became bankrupt. Shortly after, Vladimir got a job offer and Sofia helped neighbours to electrify street lights. Vladimir and Sofia quickly established themselves again financially.

The Kovalevskiys returned to Russia, but failed to secure professorships because of their radical political beliefs. Discouraged, they went back to Germany. Vladimir, who had always suffered severe mood swings, became more unstable, so they spent most of their time apart. Then, for some unknown reason, perhaps it was the death of her father they decided to spend several years together as an actual married couple. During this time their daughter, Sofia (called "Fufa"), was born. After a year devoted to raising her daughter, Kovalevskaya put Fufa under the care of her older sister, resumed her work in mathematics and left Vladimir for what would be the last time. In 1883, faced with worsening mood swings and the possibility of being prosecuted for his role in a stock swindle, Vladimir committed suicide.

That year, with the help of the mathematician Gösta Mittag-Leffler whom she had known as a fellow student of Weierstrass', Kovalevskaya was able to secure a position as a*privat-docent* at Stockholm University in Sweden. Kovalevskaya met Mittag-Leffler through his sister, actress, novelist, and playwright Anne Charlotte Edgren-Leffler. Until Kovalevskaya's death the two women shared a close friendship that was interpreted by some authors as a possibly romantic or even sexual relationship.

The following year (1884) she was appointed to a five-year position as "Professor Extraordinarius" (Professor without Chair) and became the editor of Acta Mathematica. In 1888 she won the *Prix Bordin* of the French Academy of Science, for her work on the question: "Mémoire sur un cas particulier du problème de le rotation d'un corps pesant autour d'un point fixe, où l'intégration s'effectue à l'aide des fonctions ultraelliptiques du temps". Her submission included the celebrated discovery of what is now known as the "Kovalevskaya Top", which was subsequently shown to be the only other case of rigid body motion, beside the tops of Euler and Lagrange, that is "completely integrable".

In 1889 she was appointed Professor Ordinarius (Professorial Chair holder) at Stockholm University, the first woman to hold such a position at a northern European university. After much lobbying on her behalf (and a change in the Academy's rules) she was granted a Chair in the Russian Academy of Sciences, but was never offered a professorship in Russia.

Kovalevskaya wrote several non-mathematical works as well, including a memoir, *A Russian Childhood*, plays (in collaboration with Duchess Anne Charlotte Edgren-Leffler) and a partly autobiographical novel, *Nihilist Girl* (1890).

She died of influenza in 1891 at age forty-one, after returning from a vacation to Genoa. She is buried in Solna, Sweden, at Norra begravningsplatsen.

Tributes

Sonya Kovalevsky High School Mathematics Day is a grant-making program of the Association for Women in Mathematics (AWM), funding workshops across the United States which encourage girls to explore mathematics.

The Sonya Kovalevsky Lecture is sponsored annually by the AWM, and is intended to highlight significant contributions of women in the fields of applied or computational mathematics. Past honorees have included Irene Fonseca (2006), Ingrid Daubechies (2005), Joyce R. McLaughlin (2004) and Linda R. Petzold (2003).

Figure 55 – Commemorative coin, 2000. Soviet Union postage stamp, 1951

The lunar crater Kovalevskaya is named in her honor.

The Alexander Von Humboldt Foundation of Germany bestows a bi-annual Sofia Kovalevskaya Award to promising young researchers.

Sofia Kovalevskaya has been the subject of three film and TV biographies.

- *Sofya Kovalevskaya* (1956) directed by Iosef Shapiro, starring Yelena Yunger, Lev Kosolov and Tatyana Sezenyevskaya.
- *Berget På Månens Baksida* ("A Hill on the Dark Side of the Moon") (1983) directed by Lennart Hjulström, starring Gunilla Nyroos as Sofja Kovalewsky and Bibi Andersson as Anne Charlotte Edgren-Leffler, Duchess of Cajanello, and sister to Gösta Mittag-Leffler.
- *Sofya Kovalevskaya* (1985 TV) directed by Azerbaijani director Ayan Shakhmaliyeva, starring Yelena Safonova as Sofia.
- "Little Sparrow: A Portrait of Sophia Kovalevsky" (1983), Don H. Kennedy, Ohio University Press, Athens, Ohio
- "Beyond the Limit: The Dream of Sofya Kovalevskaya" (2002), a biographical novel by mathematician and educator Joan Spicci, published by *Tom Doherty Associates, LLC*, is an historically accurate portrayal of her early married years and quest for an education. It is based in part on 88 of Sofia's letters, which the author translated from Russian to English.
- *Against the Day*, a 2006 novel by Thomas Pynchon was speculated before release to be based on the life of Sofia, but in the finished novel she appears as a minor character.
- "Too Much Happiness" (2009), short story by Alice Munro, published in the August 2009 issue of *Harper's Magazine* features Sofia as a main character. It was later published in a collection of the same name.

6.2.2 Find the meaning of the words in the dictionary and learn them:

rigid body motion; partial differentian equation; elliptic integrals; celebrated discovery; was granted professorship; grant-making program; contribution; lessons in calculus; original flair for mathematics.

6.2.3 Draw a table of the main Kovalevskaya's discoveries.

6.2.4 What position do you think would Kovalevskaya apply currently? Write her CV.

6.3 Nikolai Lobachevsky

6.3.1 Read and translate text C

Nikolai Lobachevsky was born December 1, 1792 In Makaryevo, Nizhny Novgorod Region. He died in February 24, 1856 (aged 63). His scientific field was Geometry, Alma mater – Kazan University, known for Lobachevsky geometry.

Nikolai Ivanovich Lobachevsky was a Russian mathematician and geometer, known primarily for his work on hyperbolic geometry, otherwise known as Lobachevsky geometry.

William Kingdon Clifford called Lobachevsky the "Copernicus of Geometry" due to the revolutionary character of his work.

Nikolai Lobachevsky was born either in or near the city of Nizhny Novgorod in the Russian Empire (now in Nizhny Novgorod Oblast, Russia) in 1792 to parents of Polish origin – Ivan Maksimovich Lobachevsky and Praskovia Alexandrovna Lobachevskaya. He was one of three children. His father, a clerk in a land surveying office, died when he was seven, and his mother moved to Kazan. Lobachevsky attended Kazan Gymnasium from 1802, graduating in 1807 and then received a scholarship to Kazan University, which was founded just three years earlier in 1804.

Figure 60 – Portrait by Lev Kryukov (1843)

At Kazan University, Lobachevsky was influenced by professor Johann Christian Martin Bartels, a former teacher and friend of German mathematician Carl Friedrich Gauss. Lobachevsky received a master's degree in physics and mathematics in 1811. In 1814, he became a lecturer at Kazan University, in 1816 he was promoted to associate professor, and in 1822, at the age of 30, he became a full professor, teaching mathematics, physics, and astronomy. He served in many administrative positions and became the rector of Kazan University in 1827. In 1832, he married Varvara Alexeyevna Moiseyeva. They had a large number of children (eighteen according to his son's memoirs, while only seven apparently survived into adulthood). He was dismissed from the university in 1846, ostensibly due to his deteriorating health: by the early 1850s, he was nearly blind and unable to walk. He died in poverty in 1856.

Career

Lobachevskys main achievement is the development (independently from János Bolyai) of a non-Euclidean geometry, also referred to as Lobachevsky geometry. Before him, mathematicians were trying to deduce Euclid's fifth postulate from other axioms. Euclid's fifth is a rule in Euclidean geometry which states (in John Playfair's reformulation) that for any given line and point not on the line, there is one parallel line through the point not intersecting the line. Lobachevsky would instead develop a geometry in which the fifth postulate was not true. This idea was first reported on February 23, 1826 to the session of the department of physics and mathematics, and this research was printed in 1829-1830. Lobachevsky wrote a paper about it called “A concise outline of the foundations of geometry” that was published by the Kazan Messenger but was rejected when it was submitted to the St. Petersburg Academy of Sciences for publication.

The non-Euclidean geometry that Lobachevsky developed is referred to as hyperbolic geometry. Lobachevsky replaced Playfair axiom with the statement that for any given point there exists more than one line that can be extended through that point and run parallel to another line of which that point is not part. He developed the angle of parallelism which depends on the distance the point is off the given line. In hyperbolic geometry the sum of angles in a hyperbolic triangle must be less than 180 degrees. Non-Euclidean geometry stimulated the development of differential geometry which has many applications. Hyperbolic geometry is frequently referred to as "Lobachevsky geometry" or "Bolyai–Lobachevsky geometry".

Some mathematicians and historians have wrongfully claimed that Lobachevsky in his studies in non-Euclidean geometry was influenced by Gauss, which is untrue – Gauss himself appreciated Lobachevsky published works very highly, but they never had personal correspondence between them prior to the publication. In fact out of the three people that can be credited with discovery of hyperbolic geometry – Gauss, Lobachevsky and Bolyai, Lobachevsky rightfully deserves having his name attached to it, since Gauss never published his ideas and out of the latter two Lobachevsky was the first who duly presented his views to the world mathematical community.

Lobachevsky magnum opus Geometry was completed in 1823, but was not published in its exact original form until 1909, long after he had died. Lobachevsky was also the author of New Foundations of Geometry (1835-1838). He also wrote Geometrical Investigations on the Theory of Parallels (1840) and Pangeometry (1855).

Another of Lobachevsky achievements was developing a method for the approximation of the roots of algebraic equations. This method is now known as the Dandelin-Gräffe method, named after two other mathematicians who discovered it independently. In Russia, it is called the Lobachevsky method. Lobachevsky gave the definition of a function as a correspondence between two sets of real numbers. Peter Gustav Lejeune Dirichlet gave the same definition independently soon after Lobachevsky.

E.T. Bell wrote about Lobachevsky influence on the following development of mathematics in his 1937 book “Men of Mathematics”:

“The boldness of his challenge and its successful outcome have inspired mathematicians and scientists in general to challenge other 'axioms' or accepted 'truths', for example the 'law' of causality which, for centuries, have seemed as necessary to straight thinking as Euclid's postulate appeared till Lobatchewsky discarded it. The full impact of the Lobatchewsky method of challenging axioms has probably yet to be felt. It is no exaggeration to call Lobatchewsky the Copernicus of Geometry, for geometry is only a part of the vaster domain which he renovated; it might even be just to designate him as a Copernicus of all thought”.

Honors 1858 Lobachevsky, an asteroid discovered in 1972, was named in his honour.The lunar crater Lobachevsky was named in his honour.Lobachevsky Prize, a mathematics award by the Kazan State University.Annual celebration of Lobachevsky birthday by participants of Volga Student Mathematical Olympiad

Lobachevsky is the subject of songwriter/mathematician Tom Lehrer's humorous song "Lobachevsky" from his Songs by Tom Lehrer album. In the song, Lehrer portrays a Russian mathematician who sings about how Lobachevsky influenced him: "And who made me a big success and brought me wealth and fame? Nikolai Ivanovich Lobachevsky is his name."Lobachevsky secret to mathematical success is given as "Plagiarize!", as long as one is always careful to "call it, please, research". According to Lehrer, the song is "not intended as a slur on Lobachevsky character" and the name was chosen "solely for prosodic reasons".

In Poul Anderson's 1969 fantasy novella "Operation Changeling" – which was later expanded into the fix-up novel Operation Chaos (1971) – a group of sorcerers navigate a non-Euclidean universe with the assistance of the ghosts of Lobachevsky and Bolyai. The story also contains the line, "Nikolai Ivanovich Lobachevsky is his name," possibly a nod to the Tom Lehrer song.

Roger Zelazny science fiction novel Doorways in the Sand contains a poem dedicated to Lobachevsky.

6.3.2 Find the meaning of the words in the dictionary and learn them:

hyberbolic geometry; mathematician; geometer; adulthood; was dismissed; to deduce; concise outline;axiom; to run parallel to another line; angle; sum of angles; triangle; to be credited with; approximation of the roote of algebraic equavitions; universe.

6.3.3 Draw a table of the main Lobachevsky’s discoveries.

6.3.4 What position do you think would Lobachevsky apply currently? Write his CV.

6.3.5 Write your CV to the position you would like to take.

6.3.6 Speak about a famous scientist.

7 Unit 7 Computational Science

7.1 Introduction to cybernetics and informatics

7.1.1 Read and translate text A:

Of all known forms of life on the Earth man is the only one to have developed a systematic procedure for storing up useful information and passing it from one generation to the next. Calculation began with two problems, one concerned with the needs of practical living, the other with the requirements of science. As problems became more complex, more powerful methods of computation were discovered. Man's technical progress is reflected in the tools he has invented. Throughout the centuries man has refined the ability to record, process and communicate information. Ultimately came the period of mechanical invention, which began to flower in the early years of the twentieth century. With the advent of automatic digital computers man has created devices that can solve complete problems without the need for human intervention during the course of solution. With the invention of servo mechanisms, vacuum tubes, memory units, transistors, and the like, man suddenly discovered he has constructed an instrument that far transcended many of his own powers. Many jobs, hitherto performed by human energy, were turned over to the new machines. Computers can perform prodigies of deductive reasoning and solve complicated problems formulated in terms of Boolean algebra.

Computers can solve the most difficult equations, remember complicated chains of operations, form images and draw pictures of them. When the information in an image is expressed in digital form, it can be manipulated mathematically rather than optically. The digital computer is now an essential tool in many areas of image processing. Computers can be adapted with some success to the problem of translating languages. The prospect of automation has become a reality in many lines of human. Computer fulfills four types of functions: 1) input-output; 2) storage; 3) arithmetic, and 4) control. The way, in which these functions are executed, differs among the various computers. A program (routine) is a complete set of instructions for doing a particular task. The process of preparing such a program is known as programming. Cybernetics is concerned with the design and construction of electrical or electronic analogs capable of performing processes carried out within a living entity including the selection and evaluation, as well as the storage of information.

Originally informatics was one of the numerous fields of cybernetics. At present informatics is an independent multifield science. Plato advised, "The principal men of our State must go and learn arithmetic, not as amateurs, but they must carry on the study until they see the nature of numbers with the mind only." The often-repeated motto on the entrance to Plato's Academy said, "Let none ignorant of geometry enter here." Aristotle said in his Metaphysics, "In their theory the Pythagoreans supposed that the whole nature is modelled on numbers, and numbers are the first things in the whole of nature; the elements of numbers are the elements of all things." Kepler affirmed, "The reality of the world consists of its mathematical relations. Mathematical laws are the true cause of phenomena." Descartes, father of modernism, said, "All nature is a vast geometrical system. Thereafter I neither admit nor hope for any principles in physics other than those which are in geometry or in abstract Maths, because, thus all the phenomena of nature are explained and some demonstration of them can be given." In Descartes' words, "Give me extension and motion and I will construct the universe."

Twenty or more years ago the word "algorithm" was unknown to most educated people; indeed, it was scarcely necessary.

7.1.2 Find in the text following words and word combinations:

накопление; полезная информация; требования науки; более мощные методы вычислений; обрабатывать информацию; без вмешательства человека в процесс решения; сервоприводные механизмы; электронные лампы; решать сложные задачи; ввод-вывод; хранение; выбор и оценка.

7.1.3 Answer the following questions:

1 What did calculation begin with? 2 When did the period of mechanical invention begin to flower? 3 What kind of devices has man created with the advent of automatic digital computers? 4 What can computers perform? 5 What functions does computer fulfill? 6 What is a program? 7 What is programming? 8 What was often repeated motto on the entrance to Plato's Academy?

7.1.4 Write out the sentences with modal verbs and translate them.

7.1.5 Write out the sentences in the Perfect Tense and translate them.

7.2 Computational Science

7.2.1 Read and translate text B:

The topics in the core of this area are central to "computational thinking'' and are at the heart of using computational power to solve problems in domains both inside and outside of traditional CS boundaries. The elective material covers topics that prepare students to contribute to efforts such as computational biology, bioinformatics, eco-informatics. computational finance, and computational chemistry.

DS Discrete Structures. The concepts covered in the core are not new but some coverage time has shifted from logic to discrete probability, reflecting the growing use of probability as a mathematical tool in computing. Many learning outcomes are also more explicit in CS201 3.

GV Graphics and Visualization. The storage of analog signals in digital form is a general computing idea, as is storing information vs. re-computing. (This outcome appears in System Fundamentals, also.)

HCI Human-Computer Interaction. Although the core hours have not increased, there is a change in emphasis within this knowledge area to recognize the increased importance of design methods and interdisciplinary approaches within the specialty.

IM Information Management. The core outcomes in this Knowledge Area reflect topics that are broader than a typical database course. They can easily be covered in a traditional database course, but they must be explicitly addressed.

IS Intelligent Systems. Greater emphasis has been placed on machine learning than in the past. Additional guidance has been provided on what is expected of students with respect to understanding the challenges of implementing and using intelligent systems.

NC Networking and Communication. There is greater focus on the comparison of IP and Ethernet networks, and increased attention to wireless networking. A related topic is reliable delivery . Here there is also added emphasis on implementation of protocols and applications.

OS Operating Systems. This knowledge area is structured to be complementary to Systems Fundamentals. Networking and Communication. Information Assurance and Security, and the Parallel and Distributed Computing Knowledge Areas. While some argue that system administration is the realm of IT and not CS. the working group believes that every student should have the capability to carry out basic administrative activities, especially those impact access control. Security and protection were electives in CC2001 while they were included in the core in CS2008. They appear in the core here as well. Realization of virtual memory using hardware and software has been moved to be an elective learning outcome (OS/Virtual Machines). Details of deadlocks and their prevention, including detailed concurrency is left to the Parallel and Distributed Computing Knowledge Area.

PD Platform-Based Development. This is a new knowledge area, which demonstrates the need for students to be able to work in parallel and distributed environments. This trend was initially identified, but not included, in the CS2008 Bod) of

Knowledge. It is made explicit here to reflect that some familiarity with this topic has become essential for all undergraduates in CS.

PL Programming Languages. For the core material, the outcomes were made more uniform and general by refactoring material on object-oriented programming, functional programming, and event-oriented programming that was in multiple knowledge areas in CC200L Programming with less mutable state and with more use of higher-order functions (like map and reduce) have greater emphasis. For the elective material, there is greater depth on advanced language constructs, type systems, static analysis for purposes other than compiler optimization, and run-time systems particularly garbage collection.

SDF Software Development Fundamentals. This new knowledge area pulls together foundational concepts and skills needed for software development. It is; derived from the Programming Fundamentals Knowledge Area in CC2001 but also draws basic analysis material from Algorithms and Complexity, development process from Software Engineering, fundamental data structures from Discrete Structures, and programming language concepts from Programming Languages. Material specific to particular programming paradigms (e.g. object-oriented, functional) has been moved to Programming Languages to allow for a more uniform treatment with complementary material distribute lecture notes and course materials to students, and publish papers and articles. Individuals use the Internet for communication, entertainment, finding information, and buying and selling goods and services.

7.2.2 Give the full form of abbreviations and translate them:

CS; DS; GV; HCI; IM; IS; NC; OS; PD; PL; SDF.

7.2.3 Answer the following questions:

1 What does the elective material cover? 2 What courses are considered elective and obligatory? 3 What courses are considered obligatory in your curriculum? 4 What courses are considered elective in your curriculum?

7.2.4 Find in the text adjectives in the degrees of comparison. Write three forms (positive, comparative, superlative) and translate them.

7.3 How the Internet works

7.3.1 Read and translate text C:

The term Internet access refers to the communication between a residence or a business and an ISP that connects to the Internet. Access falls into two broad categories: dedicated and dial-up. With dedicated access, a subscriber's computer remains directly connected to the Internet at all times by a permanent, physical connection. Most large businesses have high-capacity dedicated connections; small businesses or individuals who desire dedicated access choose technologies such as digital subscriber line (DSL) or cable modems, which both use existing wiring to lower cost. A DSL sends data across the same wires that telephone service uses, and cable modems use the same wiring that cable television uses. In each case, the electronic devices that are used to send data over the wires employ separate frequencies or channels that do not interfere with other signals on the wires. Thus, a DSL Internet connection can send data over a pair of wires at the same time the wires are being used for a telephone call, and cable modems can send data over a cable at the same time the cable is being used to receive television signals. The user usually pays a fixed monthly fee for a dedicated connection. In exchange, the company providing the connection agrees to relay data between the user's computer and the Internet.

Dial-up is the least expensive access technology, but it is also the least convenient. To use dial-up access, a subscriber must have a telephone modem, a device that connects a computer to the telephone system and is capable of converting data into sounds and sounds back into data. The user's ISP provides software that controls the modem. To access the Internet, the user opens the software application, which causes the dial-up modem to place a toll-free telephone call to the ISP. A modem at the ISP answers the call, and the two modems use audible tones to send data in both directions. When one of the modems is given data to send, the modem converts the data from the digital values used by computers-numbers stored as a sequence of 1s and 0s-into tones. The receiving side converts the tones back into digital values. Unlike dedicated access technologies, a dial-up modem does not use separate frequencies, so the telephone line cannot be used for regular telephone calls at the same time a dial-up modem is sending data.

All information is transmitted across the Internet in small units of data called packets. Software on the sending computer divides a large document into many

7.3.2 Find the meaning of the following words and learn them:

access; ISP; dedicated or dial-up access; directly connected; high-capacity dedicated connection; DSL; wiring; separate frequency; to relay data; software application; toll-free telephone call; digital values; convert; packet.

7.3.3 Answer the following questions:

1 What does the term Internet access refer to? 2 What are two categories of Internet access? 3 How does DSL work? 4 What equipment must a dial-up subscriber have?

7.3.4 Write summary of the texts A, B, C.

7.4 Computer Security

7.4.1 Read and translate text D**:**

Computing magazines often define information assurance as “the technical and managerial measures designed to ensure the confidentiality, possession or control, integrity, authenticity, availability, and utility of information and information systems.” This information may be in storage, processing, or transit, and the threats to it can be accidental or intentional.

Protecting information resources is not easy. Network technology advances so quickly that IT experts are constantly challenged to keep up. The plethora of valuable information stored on computers and sent through the Web provides great potential for hackers and scammers to infiltrate computer security.

There are two main types of hackers. Some hackers use their computers to break into companies' or other people's computers to steal information, such as credit card numbers. This type of computer criminal uses increasingly sophisticated methods to obtain personal information. Other types of hackers are more interested in damaging the receivers' computers and do this by sending viruses through Web sites or e-mail.

Spyware is a term used to describe a program that is put on a computer without the user's permission, and usually without the user's knowledge. A spyware program runs in the background and keeps track of the programs the user runs and the Web sites the user visits. Some spyware tracks the user's keystrokes and extracts passwords and other information as they type. It then uses the information gathered to display certain advertisements or forces the user's browser to display certain Web sites or search results. Most spyware is written for the Windows operating system.

Spyware can be installed on a computer in any of the following ways:

- Piggybacked software installation: Some software applications, and especially free software downloads, install spyware as part of the program installation.
- Drive-by download: Some Web sites automatically try to download and install spyware on the user's machine. Users may get a pop-up warning, but not if the security setting is too low.
- Browser additions: This type of spyware adds enhancements, such as a toolbar, an animated pal, or additional search boxes, to the user's Web browser. Some enhancements, also known as browser hijackers, embed themselves deep in the user's computer, making it very hard to remove them.
- Masquerading as anti-spyware: Some spyware advertises that it can remove spyware, when, in reality, they are actually installing additional spyware.

Not only does spyware infringe upon users' privacy, but it can also slow down computers. Many spyware programs use up most of the computer's random access memory (RAM) and processor power, preventing other applications from using these resources. In addition, many spyware programs generate popup advertisements that slow down the user's Web browser, reset the user's homepage to display advertisements every time she opens the Web browser, and redirect the user's Web searches. Some of the more malicious spyware programs modify the user's firewall settings, increasing the opportunities for more spyware and viruses to enter the user's computer.

7.4.2 Find the meaning of the words in the dictionary and learn them:

headlined; computer security; managerial; confidentiality; possession; integrity; authenticity; utility; accidental; intentional; network; sophisticated; threats; describe; background; perfection of methods and the means; keystroke; gather; advertisement; piggybacked software installation; drive-by-download; browser add-ons; masquerading as anti-spyware; infringe; memory; malicious; opportunity.

7.4.3 Read the summary to the text and correct if there are some inconsistency with the content.

1 The article is headlined "Computer security". 2 The main idea of the article is the problems associated with the protection of information resources. 3 The author starts by telling the reader that the rapid development of spyware has a negative aspect. 4 The problems related to enhancing the security of the computer system, are difficult. 5 The author writes that they require constant, tireless attention of the user. 6 Development of spyware requires a constant effort to improve the application of methods and means of protection. 7 Modern information technology can detect almost all the known virus programs. 8 In addition, the behavior simulation technology designed to allow to identify the newly created virus programs. 9 I found the article interesting, because the need to protect the information comes first. 10 I think the article is interesting, informative and informative. 11 It broadens my horizons of knowledge in the field of computer security. 12 I advise you to read this article in order to avoid loss and damage valuable information.

7.4.4 Write the summary of the text.

8 Unit 8 New Media

8.1 What is new media?

8.1.1 Read text A and speak about new media:

New media is a broad term that emerged in the later part of the 20th century to encompass the amalgamation of traditional media such as film, images, music, spoken and written word, with the interactive power of computer and communications technology, computer-enabled consumer devices, and most importantly the Internet. New media holds out a possibility of on-demand access to content anytime, anywhere, on any digital device, as well as interactive user feedback, creative participation, and community formation around (lie media content. What distinguishes new media from traditional media is not the digitizing of media content into bits, but the dynamic life of the "new media" content and its interactive relationship with the media consumer. This dynamic life moves, breathes, and flows with pulsing excitement in real time. Thus, a high-definition digital television broadcast of a film viewed on a digital plasma TV is still an example of traditional media, while an "analog" paper poster of a local rock band that contains a web address where fans coil find information and digital music downloads is an example of new media communication. Most technologies described as "new media" are digital, often having characteristics of being manipulated, networkable, dense, compressible interactive, and impartial. Some examples may be the Internet, websites, computer multimedia, computer games, CD-ROMS, and DVDs. New media is not television programs, feature films, magazines, books, or paper-based publications – unless they contain technologies that enable digital interactivity, such as graphic tags containing web-links.

History

In the 1960s connections between computing and radical art began to grow stronger. It was not until the 1980s that Alan Kay and his coworkers at Xerox PARC began to give the power of a personal computer to the individual, rather than have a big organization be in charge of this. "In the late 1980s and early 1990s, however, we seem to witness a different kind of parallel relationship between social changes and computer design."

Until the 1980s media relied primarily upon print and analog broadcast models, such as those of television and radio. The last twenty-five years have seen the rapid transformation into media which are predicated upon the use of digital computers, such as the Internet and computer games. However, these examples are only a small representation of new media. The use of digital computers has transformed the remaining "old" media, as suggested by the advent of digital television and online publications. Even traditional media forms such as the printing press have been transformed through the application of technologies such as image manipulation software like desktop publishing tools.

According to W. Russell Neuman, "We are witnessing the evolution of a universal interconnected network of audio, video, and electronic text communications that will blur the distinction between interpersonal and mass communication and between public and private communication." Neuman argues that new media will:

- alter the meaning of geographic distance;
- allow for a huge increase in the volume of communication;
- provide the possibility of increasing the speed of communication;
- provide opportunities for interactive communication;
- allow forms of communication that were previously separate to overlap and interconnect.

What is new media? The New Media Reader defines new media by using some simple and concise propositions: New Media versus Cyberculture – Cyberculture is the study of various social phenomena that are associated with the Internet and network communications (blogs, online multi-player gaming), whereas new media is concerned more with cultural objects and paradigms (digital to analog television, iPhones).

New Media as Computer Technology Used as a Distribution Platform – new media are the cultural objects which use digital computer technology for distribution and exhibition, e.g. (at least for now) Internet, websites, computer multimedia, Blu-ray disks, etc. The problem with this is that the definition must be revised every few years. The term "new media" will not be "new" anymore, as most forms of culture will he distributed through computers.

New Media as Digital Data Controlled by Software – the language of new media is based on the assumption that, in fact, all cultural objects that rely on digital representation and computer-based delivery do share a number of common qualities. New media is reduced to digital data that can be manipulated by software as any other data. Now media operations can create several versions of the same object. An example is an image stored as matrix data which can be manipulated and altered according to the additional algorithms implemented, such as color inversion, gray-scaling, sharpening, rasterizing, etc.

New Media as the Mix Between Existing Cultural Conventions and the Conventions of Software – new media today can be understood as the mix between older cultural conventions for data representation, access, and manipulation and newer conventions of data representation, access, and manipulation. The "old" data are representations of visual reality and human experience, and the "new" data is numerical data.

Globalization and new media

The rise of new media has increased communication between people all over the world and the Internet. It has allowed people to express themselves through blogs, websites, pictures, and other user-generated media. Globalization shortens the distance between people all over the world by the electronic communication.

New media have created virtual realities that are becoming extensions of the world we live in. With the creation of Second Life people have even more control over this virtual world where anything that a participant can think of in his mind can become a reality in Second Life.

New media changes continuously due to the fact that it is constantly modified and redefined by the interaction between the creative use of the masses, emerging technology, cultural changes, etc.

8.1.2 Find in text English equivalents to the following Russian phrases:

слияние традиционных средств информации с Интернетом; потребительские приборы, появившиеся благодаря компьютеру; предлагать возможность; доступ по требованию; а также; обратная связь пользователя; творческое участие; содержание средств информации, цифровое телевещание; художественные фильмы; быть на попечении (отвечать за); издания в компьютерной сети; программированные средства управления построением изображений, настольные издательские системы; межличностные связи; краткие предложения; различные явления; коллективная игра в сети; использовать для распределения и показа; корректирован; определения; цифровая информация, управляемая программными средствами; основываться на предположении; основываться на цифровом представлении; иметь ряд общих качеств; правила представления информации; цифровые данные; средства, созданные пользователем; мир, в котором мы живем; все, что участник может представить в уме; постоянно изменяться; благодаря тому, что.

8.1.3 Answer the following questions:

1 What do you understand by the term “new media”? 2 What distinguishes new media from traditional media? 3 Give examples of traditional media and new media communication. 4 What characteristics have most new media technologies got? 5 Can TV be called new media of communication and in what case? 6 What were the early media relied on? 7 What helped to transform the old media into new one? 8 How will new media change according to W. Neuman? 9 What can you say about new media versus cyberculture? 10 How is new media constantly changed?

8.1.4 Make up a summary of the text.

8.2 The computing era

8.2.1 Read text B and say what scientists are mentioned in the text and what their discoveries are:

Nobody knows who built the first computer. Some people say that humans were the first computers. Human computers got bored doing the same math over and over again.

A cashier, for example, used to make change every day in her head or with a piece of paper. That took a lot of time and people made mistakes. So people made machines that did those same things over and over. The abacus, the slide rule, the astrolabe are samples of automated calculation machines.

This part of computer history is called the “history of automated calculation.” At the end of the Middle Ages people in Europe thought math and engineering were more important. In 1623 Wilhelm Schickard made a mechanical calculator. Other Europeans made more calculators after him. They were not modern computers because they could only add, subtract, and multiply. Some people wanted to be able to tell their machine to do different things. For example, they wanted to tell the music box to play different music. One of the first examples of this was built by Hero of Alexandria (10-70 A.D.). He built a mechanical theater, which performed a play lasting 10 minutes and was operated by a complex system of ropes and drums. These ropes and drums were the language of the machine – they told what the machine did. Some people think that this is the first programmable machine.

In 1801 Joseph Marie Jacquard used punched paper cards to tell his textile loom what kind of pattern to weave. He could use punch cards to tell the loom what to do, and he could change the punch cards, which means he could program the loom to weave the pattern he wanted. This means the loom was programmable. This part of computer history is called the “historyof programmable machines.”

Modem computers were made when Charles Babbage had a bright idea. He wanted to make a machine that could do all the boring parts of mathematics, (like the automated calculators) and could be told to do them different ways (like the programmable machines). Charles Babbage was the first to make a design of a fully programmable mechanical computer. He called it the “the analytical engine.” Because Babbage did not have enough money and always changed his design when he had a better idea, he never built his analytical engine.

As time went on, computers got more and more popular. Herman Hollerith figured out how to make a machine that would automatically add up information that the Census Bureau collected. The Computing Tabulating Recording Corporation (which later became

IBM) made his machines. People were happy until their machines broke down, got jammed, and had to be repaired. This is when the Computing Tabulating Recording Corporation invented technical support.

Because of machines like this, new ways of talking to these machines were invented, and new types of machines were invented, and eventually the computer that we all know and love today was born. Modern computers have changed very much. They are able to control traffic lights, cars, or locks. Most modern computers can be used to play music or video. The basic principle is still the same though: the computer has a set of rules, usually called an algorithm. Based on these rules it changes information.

8.2.2 Answer the following questions:

1 What part of computer history is considered "the history of automated calculation"? 2 Give examples of the first automated calculation machines. 3 Why were they not like modern computers? 4 What were the first programmable machines? Describe them. 5 When did the history of programmable machines come? 6 Who contributed to the appearance of a programmable mechanical computer? 7 What prevented people to be satisfied with the machine designed by H. Hollerith? 8 What important thing favored the improvement of the computer? 9 How do programmers give tasks to computers? 10 What can modern computers do?

8.2.3 Put the verbs given in brackets in the necessary form:

1 Cashiers often (to make) mistakes doing a lot of calculations every day.
2 Punched cards (to use) by J. M. Jacquard to program his loom. 3 People greatly (to change) computers lately. 4 During the experiment the machine (to break) down and (must repair). 5 Our programmer (to write) programs for the computer all day long yesterday. 6 He (to finish) his work before7 o'clock. 7 When the lesson (to be over), we (to switch) the computer off. 8 What idea Charles Babbage (to have)? He (to design) a fully programmable mechanical computer. 9 We (to use) computers for three hours to solve those mathematical problems. 10 The problems (not to solve) before the necessary

algorithms (to input) into the computer.10 Read text and (to speak) about the ways of computer improvements in the 20th century.

8.2.4 Make up a plan of the text and retell it according to it.

8.3 Steps in computer development

8.3.1 Read text C and speak about computer development:

In the first half of the 20th century scientists started using computers, mostly because scientists had a lot of mathematics to figure out and wanted to spend more of their time thinking about the secrets of the universe instead of spending hours adding numbers together. So they put together computers. These computers used analog circuits, making them very hard to be programmed. Then, in the 1930s, they invented digital computers, which made them easier to program. Nearly all modern computers use the stored-program architecture in some form. It has become the main concept which defines a modem computer. Most of the technologies used to build computers have changed since the 1940s, but many current computers still use the von-Neumann architecture.

In the 1950s computers were built out of mostly vacuum tubes. Transistors, being smaller and cheaper, replaced vacuum tubes in the 1960s. They also need less power and don’t break down as much as vacuum tubes. In the 1970s technologies were based on integrated circuits. Microprocessors, such as the Intel 4004 made computers smaller and cheaper, faster and more reliable. By the 1980s computers became small and cheap enough to replace mechanical controls in things like washing machines. The 1980s also saw home computers and personal computer. With the evolution of the Internet, personal computers are becoming as common as the television and the telephone in the household.

In 2005 Nokia started to call some of its mobile phones (the N-series) “multimedia computers” and after the launch of the Apple iPhone in 2007, many are now starting to add the smartphone category among “real” computers.

Kinds of computers

There are three types of computers: desktop computers, mainframes, and embedded computers. A “desktop computer” is a small machine that has a screen (which is not part of the computer). Most people keep them on top of a desk, that is why they are called “desktop computers.” “Laptop computers” are computers small enough to fit on your lap. This makes them easy to carry around. Both laptops and desktops are called personal computers, because one person ata time uses them for things like playing music, surfing the Web, or playing video games.

There are bigger computers that many people at a time can use. These are called “mainframes,” and these computers do all the things that make things like the Internet work. You can think of a personal computer like this: the personal computer is like your skin: you can see it, other people can see it, and through your skin you feel wind, water, air, and the rest of the world. A mainframe is more like your internal organs: you (hopefully) never see them, and you barely even think about them, but if they suddenly went missing, you would have some very big problems.

There is another type of computer, called an embedded computer. An embedded computer is a computer that does one thing and one thing only and usually does it very well. For example, an alarm clock is an embedded computer: it tells the time. Unlike your personal computer, you cannot use your clock to play Tetris. Because of this, we say that embedded computers cannot be programmed, because you cannot install programs like Tetris on your clock. Some mobile phones, automatic teller machines, microwave ovens, CD players, and cars are examples of embedded computers. Home computers have a lot of applications. Among them are the following: playing computer games, writing, solving mathematical problems, looking for things on the Internet, watching TV and films, listening to music, communicating with other people.

8.3.2 Answer the following questions:

1 What forced scientists to develop and use computers? 2 Whose architecture is used in modern computers? 3 What type of circuits made computers easier to program? Why? 4 What advantages had transistors over vacuum tubes? 5 When and what devices replaced transistors in computers? 6 What made computers more reliable? 7 When did personal computers appear? 8 What main types of computers do you know? 9 Give examples of embedded computers. 10 Where do home computers find application?

8.3.3 Speak about steps in computer development.

8.3.4 Fill in the blanks with the necessary words.

1 It is interactive relationship with the media consumer that new media… from traditional media.

a) disconnects; b) discharges; c) distinguishes; d) disintegrates

2 New media provides the possibility of increasing the speed of interactive...

a) consideration; b) computation; c) consumption; d) communication

3 The development of new media has … communication between people all over the world and the Internet.

a) included; b) increased; c) installed; d) investigate

4 Ch. Babbage's idea of a fully … mechanical device seemed to be the basis for building today's computer.

a) processing; b) predominant; c) provided; d) programmable

5 A device that has input and output represented in the form of physical quantities is a … computer.

a) digital; b) analog; c) hybrid; d) modern

6 The discovery of … made computers smaller, cheaper, faster, and more reliable.

a) integrated circuits; b) transistors; c) vacuum tubes; d) capacitors

7 Mobile phones, microwave ovens, cars are examples of … computers.

a) desktop; b) mainframe; c) embedded; d) analog

8 The motherboard is connected to a … that provides electricity
to the entire computer.

a) sound card; b) power supply; c) hard disk; d) floppy drive

8.3.5 Write out the sentences with verbals (Participle I, Participle II, Gerund, Infinitive) name their functions in the sentences. Translate the sentences.

9 Unit 9. Computors architecture

9.1 Working methods of a computer

9.1.1 Read and translate text A:

Computers store data and the instructions telling them what to do with the data as numbers, because computers can do things with numbers very quickly. These data are stored as binary symbols (1s and 0s). A 1 or a 0 symbol stored by a computer is called a bit, which comes from the words binary digit. Computers can use many bits together to represent instructions and the data that these instructions use. A list of these instructions is called a program and stored on the computer's hard disk. Computers use memory called "RAM" as a space to carry out the instructions and store data while it is doing these instructions. When the computer wants to store the results of the instructions for later, it uses the hard disk.

An operating system tells the computer how to understand what jobs it has to do, how to do these jobs, and how to tell people the results. It tells the electronics inside the computer, or "hardware," how to work to get the results it needs. This lets most computers have the same operating system, or list of orders to tell it how to talk to the user, while each computer can have its own computer programs or list of jobs to do what its user needs. When a user needs to use a computer for something different, the user can learn how to use a new program.

One of the most important jobs that computers do for people is helping with communication. Communication is how people share information. Computers have helped people to move forward in science, medicine, business, and learning, because they let experts from anywhere in the world to work with each other and share information. They also let other people communicate with each other, do their jobs almost anywhere, learn about almost anything, or share their opinions with each other. The Internet is the thing that lets people communicate between their computers.

Software development (also known as software, application development; software design, software engineering) is the development of a software product in a planned and structured process. This software could be produced for a variety of purposes – the three most common purposes are: to meet specific needs of a specific client/business, to meet a perceived need of some set of potential users, or for personal use. The term software development is often used to refer to the activity of computer programming, which is the process of writing and maintaining the source code, whereas the broader sense of the term includes all that is involved between the conception of the desired software through to the final manifestation of the software. Therefore, software development may include research, new development, modification, reuse, re-engineering, maintenance, or any other activities that result in software products.

9.1.2 Answer the following questions:

1 How are data stored on the computer? 2 What is a bit? 3 What are hard disks used for? 4 What is the function of an operating system? 5 How can people share information with each other? 6 What have computers helped people to do? 7 What are the main activities of the software? 8 What purposes is software produced for?

9.1.3 Make up couples or groups of words close in their meaning:

power, device, possibility, digit, tool, community, relationship, information, energy, engine, transformation, advent, purpose, usage, arrival, memory, instruction, connection, proposition, education, aim, piece, exhibition, construction, assumption, computation, unit, data, journal, bit, concept, kind, basis, screen, storage, network, architecture, universe, current, command, display, motor, mistake, show, suggestion, foundation, distinction, application, society, number, learning, type, idea, web, error, calculation, electricity, world, magazine, difference;

to emerge, to encompass, to shorten, to discover, to go missing, to demand, to alter, to transform, to modify, to appear, to apply, to supply, to do fine, to provide, to require, to change, to control, to calculate, to increase, to rise, to figure out, to check, to compute, to determine, to use, to cover, to convert, to reduce, to invent, to look for, to break down, to store, to perform, to help, to advance, to include, to search, to involve, to develop, to define, to check, to compute;

principle, whole, digital, common, following, concise, huge, small, rapid, different, full, movable, important, broad, large, typical, numerical, mobile, brief, big, wide, usual, significant, next, main, various, quick, little, fast, complete, short, general, entire.

9.2 Computers architecture

9.2.1 Read and translate text B:

Computers come in different forms, but most of them have a common architecture. All computers have a CPU. All computers have some kind of data bus which lets them get inputs or output things to the environment. All computers have some form of memory. These are usually chips (integrated circuits) which can hold information. Many computers have some kind of sensors, which lets them get input from their environment.

Many computers have some kind of display device, which lets them show output. They may also have other connected peripheral devices. A computer has several main parts. When comparing a computer to a human body, the CPU is like a brain. It does most of the “thinking” and tells the rest of the computer how to work. The CPU is on the motherboard, which is like the skeleton. It provides the basis for where the other parts go, and carries the nerves that connect them to each other and the CPU. The motherboard is connected to a power supply, which provides electricity to the entire computer. The various drives (CD drive, floppy drive, and USB drive) act like eyes, ears, and fingers, and allow the computer to read different types of storage, in the same way that a human can read different types of hooks. The hard drive is like a human's memory, and keeps track of all the data stored on the computer. Most computers have a sound card or another method of making sound, which is like vocal cords, or a voice box. Connected to the sound card are speakers, which are like a mouth, and are where the sound comes out. Computers might also have a graphics card, which helps the computer to create visual effects, such as 3D environments, or more realistic colors.

9.2.2 Answer the following questions:

1 Describe the computer's architecture. 2 What is the CPU and what is its function? 3 What is motherboard? 4 What is the role of different drives in the computer? 5 What is the function of sound card?

9.2.3 Transform sentences containing the modal verbs into the Past and Future Tense:

1 The user can learn how to use programs. 2 Due to the Internet you may easily communicate with other people. 3 The motherboard must be connected to a power supply to provide electricity to the entire computer. 4 Various drives can allow the computer to read different types of storage like a human can read different types of books. 5 A computer may have a sound card and a graphic card. 6. Children need computers to play computer games. 7 Embedded computers cannot be programmed because you cannot install programs with games on your clock. 8 Software may include research, new development, modification, etc. 9 The definition of new media must be revised every few years. 10 Computers can use many bits together to represent instructions and data that the instructions must use.

9.2.3 Make up a summary of the texts A and B.

10 Unit 10. Modern Portable Computers and their applications

10.1 A Notebook or a Modern Laptop

10.1.1 Read text A and say what you've got to know about portable computers:

A notebook is considered to be a personal computer designed for mobile use that is small and light enough for a person to rest on their lap. A laptop integrates most of the typical components of a desktop computer, including a display, a keyboard, a pointing device (a touchpad, also known as a trackpad, and/or a pointing stick), and speakers into a single unit. A laptop is powered by mains electricity via an AC adapter, and can be used away from an outlet using a rechargeable battery. A laptop battery in new condition typically stores enough energy to use the laptop for three to five hours, depending on the computer usage, configuration, and power management settings. The laptop being plugged into the mains, the battery charges, whether or not the computer is running.

Modern laptops weigh 1.4 to 5.4 kg. Most laptops are designed in the flip form factor to protect the screen and the keyboard when closed. Modern tablet laptops have a complex joint between the keyboard housing and the display permitting the display panel to swivel and then lie flat on the keyboard housing. Portable computers, originally monochrome CRT-based and developing into the modern laptop, were originally used mostly for specialized field applications such as the military, accountants, and sales representatives. Portable computers becoming smaller, lighter, and cheaper, and screens becoming larger and of better quality, laptops found very wide application for all purposes.

History of laptops

As the personal computer became feasible in the early 1970s, the idea of a portable personal computer appeared. A "personal, portable information manipulator" is known to be imagined and described by Alan Kay in 1972. The IBM 5100, the first commercially available portable computer, appeared in September 1975, and was based on the SCAMP project (Special Computer APL Machine Portable) prototype.

8-bit CPU machines became widely accepted, the number of portables having increased rapidly. We know the first laptop to use the flip form factor was demonstrated in the early 1980s. It was the Epson HX-20 which had a LCD screen, a rechargeable battery, and a calculator-size printer in a 1.6 kg chassis.

From 1983 onward, several new input techniques were developed and involved in laptops, including the touchpad (in 1983), the pointing stick (in 1992), and handwriting recognition (in 1987). Some CPUs, such as the 1990Intel i386SL, were designed to use minimum power to increase battery life of portable computers.

Classification

The general term "laptop" can be used to refer to a number of classes of small portable computers: Full-size laptop – a laptop which measures at least 11 inches across, which is the minimum specialized field applications; LCD screen; width to allow a full-size keyboard. The first laptops were the size of a standard U.S. "A-size" notebook sheet of paper (8'/2 * 11 inches), but later "A4-size" laptops were introduced, which were the width of a standard ISO 216 A4 sheet of paper (297 mm), and added a vertical column of keys to the right and wider screens.

Netbook is a smaller, lighter, more portable laptop. It is also usually cheaper than a full-size laptop, but has fewer features and less computing power. Smaller keyboards can be more difficult to operate. Ultra-thin laptop – a newer class of laptops which are very thin and light. Tablet PC – these have touch screens. There are "convertible tablets" with a full keyboard where the screen rotates to be used a top the keyboard, and "slate" form-factor machines which are usually touch-screen only.

Rugged laptops – engineered to operate in tough conditions such as mechanical shocks, extreme temperatures, wet and dusty environments.

10.1.2 Translate the terms used in text A:

desktop computer; a keyboard; a keyboard housing; a touchpad; a single unit; alternating current adapter; outlet; rechargeable battery; power management settings; modern tablet laptops; a complete joint; cathode-ray tube based computers; specialized field applications; accountants and sales representatives; better quality; a calculator-size printer; several input techniques; handwriting recognition; central processing unit; full-size laptops; tablet personal computers; convertible tablets; touch screen; mechanical shocks; wet and dusty environments;

to run the laptop; to be plugged in the main; to design in a flip form; to protect the screen; to permit the display to swivel; to increase rapidly; to increase the life of a computer; to develop and involve in laptops; to operate in tough conditions; to add a vertical column of keys; to include the pointing stick; to depend on computer usage; to refer to a number of classes.

10.1.3 Answer the following questions:

I What is a notebook? 2 Why is a notebook often called a laptop? 3 What components does a laptop consist of? 4 How is a laptop powered and how long can it work? 5 What were laptops originally used for? 6 Who first described the idea of a portable computer? 7 When did the first portable computers appear? 8 What new input techniques have been developed in laptops since the 1980s? 9 What are the main classes of laptops? 10 What distinguishes different classes of laptops?

10.1.4 Translate and analyze the infinitive constructions in the following sentences:

1 A notebook is considered to be a personal computer designed for mobile use that is small and light enough for a person to rest on their lap. 2 Most laptops are designed in the flip form factor to protect the screen and the keyboard when closed. 3 Modern tablet laptops have a complex joint between the keyboard housing and the display permitting the display panel to swivel and then lie flat on the keyboard housing. 4 A “personal, portable information manipulator” is known to be imagined and described by Alan Kay in 1972. 5 We know the first laptop to use the flip form factor was demonstrated in the early 1980s. 6 Some CPUs were designed to use minimum power to increase battery life of portable computers. 7 The general term “laptop” can be used to refer to a number of classes of small portable computers. 8 Smaller keyboards can be more difficult to operate. 9 Rugged laptops – engineered to operate in tough conditions such as mechanical shocks, extreme temperatures, wet and dusty environments.

10.2 Classes of Laptops

10.2.1 Read text B and speak about types of portable computers:

A desktop computer is a laptop that provides most of the capabilities of a desktop computer, with a similar level of performance. Desktop replacements seem to be larger and heavier than standard laptops. They contain more powerful components and have a 15" or larger display. They are bulkier and not as portable as other laptops, and their operation time on batteries is typically shorter; they are intended to be used as compact and transportable alternatives to a desktop computer.

Some laptops in this class use a limited range of desktop components to provide better performance for the same price at the expense of battery life, a few of those models having no battery. These, and sometimes desktop replacement computers in general, are sometimes called desktops, a portmanteau of “desktop” and “notebook”.

In the early 2000s desktops were more powerful, easier to upgrade, and much cheaper than laptops, but in later years laptops have become much cheaper and more powerful. Most peripherals are available in laptop-compatible USB versions which minimize the need for internal add-on cards.

A **subnotebook** or ultraportable is a laptop designed and marketed with an emphasis on portability (small size, low weight, and often longer battery life) that retains performance close to that of a standard notebook. Subnotebooks are usually smaller and lighter than standard laptops, weighing between 0.8 and 2 kg; the battery life can exceed 10 hours when a large battery or an additional battery pack is installed.

To achieve the size and weight reductions, ultra-portables use 13" and smaller screens (down to 6.4"), have relatively few ports, employ expensive components designed for minimal size and best power efficiency, and utilize advanced materials and construction methods. Most subnotebooks achieve a further portability improvement by omitting an optical / removable media drive. In this case they may be paired with a docking station that contains the drive and optionally more ports or an additional battery.

The term “subnotebook” is reserved to laptops that run general-purpose desktop operating systems.

Netbooks (sometimes also called mininotebooks or ultraportables) are the area branch of subnotebooks, a rapidly evolving category of small, lightweight, economical, energy-efficient, and especially suited for wireless communication and Internet access. The origins of the netbook can be traced to the Network Computer (NC) concept of the mid-1990s. In March 1997 Apple Computer introduced the e-mail 300 as a subcompact laptop that was a cross between the Apple Newton PDA and a conventional laptop computer.

Netbooks are intended to rely heavily on the Internet for remote access to web-based applications and are targeted increasingly at cloud computing users who rely on servers and require a less powerful client computer. Netbooks typically have less powerful hardware than larger laptop computers. Some netbooks do not even have a conventional hard drive. Such netbooks use solid-state storage devices instead, as they require less power, are faster, lighter, and generally more shock-resistant, but with much less storage capacity.

Netbooks offer several distinct advantages in educational settings. First, their compact size and weight make for an easy fit in student work areas. Similarly, the small size makes netbooks easier to transport than heavier, larger-sized traditional laptops. Despite the small size, netbooks are fully capable of accomplishing most school-related tasks, including word processing, Power Point presentations, access to the Internet, multimedia playback, and photo management.

Netbooks have the potential to change the way students and teachers interact, and have many practical applications in the classroom setting. One major implication of netbooks in schools is cloud computing. Cloud computing eliminates many of the technology related headaches that we have become accustomed to, including incompatability between home computers and school computers, “data loss” due to computer crash, and printer failure.

Virtually all netbooks have wireless Internet connections, allowing complete access to free online applications and servers. It is well-known that students with laptops do more and higher quality writing, have access to more information, which improves data analysis skills, and that student-centered learning is more easily accomplished. Student-centered learning, a growing trend in education recently, increases student motivation, cultivates critical thinking and problem solving, and fosters positive student collaboration.

10.2.2 Answer the following questions:

1 What is a desktop replacement computer? 2 Compare a desktop replacement computer with a standard laptop. 3 How do people sometimes call desktop replacement computers? 4 Describe a subnotebook comparing it with a standard laptop. 5 How do ultra-portables achieve improvements in portability? 6 What kind of laptops are netbooks? 7 What are netbooks aimed at? 8 What are the main advantages and disadvantages of netbooks in comparison with larger laptop computers? 9 Where do netbooks find practical application? 10 What do students acquire using netbooks?

10.2.3 Find in texts A and B words close in their meaning to the words given below:

Example: To use – to apply, to employ, to utilize; an aim – a purpose, a target, etc.

To use, to let, to unite, to involve, to energize, to keep, to operate, to insert, to defend, to compute, to supply, to reduce, to perfect, to let, to suggest, to communicate, to finish.

An aim, a screen, a touchpad, a device, a notebook, memory, energy, application, a branch, data, method, an idea, characteristics, abilities, variant, education, opportunity, error.

Movable, little, common, usual, up-to-date, compact, broad, several, mighty, massive, brief, distant, usual, light.

Mainly, usually, quickly, particularly, not long ago.

10.2.4 Write a summary of text B

10.3 Text C. Tablet Personal Computers

10.3.1 Read text C and speak about types of tablet computers:

A tablet PC is a laptop PC equipped with a stylus or a touchscreen. Tablet PCs may be used where notebooks are impractical or unwieldy, or do not provide the needed functionality. The term tablet PC was made popular in a product announced in 2001 by Microsoft. Tablet PCs are personal computers where the owner is free to install any compatible application or operating system. Other tablet computer devices, such as eBook readers or PDAs, do not provide this option and are generally considered another category.

Tablet PCs typically incorporate small (21-36 cm) LCD screens and are popular in health care, education, hospitality, and field work. Applications for field work are sure to often require a tablet PC that has rugged specifications ensuring long life by resisting heat, humidity, and drop / vibration damage.

Booklet PCs are dual screen tablet computers that fold like a book. Typical booklet PCs are equipped with multi-touch screens and penwriting recognition capabilities. They are designed to be used as digital day planners, Internet surfing devices, project planners, music players, and displays for video, live TV, and e-reading.

Slate computers, which resemble writing slates, are tablet PCs without a dedicated keyboard. For text input, users rely on handwriting recognition via an active digitizer, touching an on-screen keyboard using finger tips or a stylus, or using an external keyboard that can usually be attached via a wireless or USB connection.

Convertible notebooks have a base body with an attached keyboard. They more closely resemble modern laptops, and are usually heavier and larger than slates. Typically, the base of a convertible attaches to the display at a single joint called a swivel hinge or rotating hinge. The joint allows the screen to rotate through 180 and fold down on top of the keyboard to provide a flat writing surface. Convertibles are by far the most popular formfactor of tablet PCs, because they still offer the keyboard and pointing device (usually a trackpad) of older notebooks, for users who do not use the touch screen display as the primary method of input.

Hybrids share the features of the slate and convertible by using a detachable keyboard that operates in a similar fashion to a convertible when attached. Hybrids are not to be confused with slate models with detachable keyboards; detachable keyboards for pure slate models do not rotate to allow the tablet to rest on it like a convertible.

Tablets versus traditional notebooks

The advantages and disadvantages of tablet PCs are highly subjective measures. What appeals to one user may be exactly what disappoints another.

Advantages:

- Usage in environments not conducive to a keyboard and mouse such as lying in bed, standing, or handling with a single hand.
- Lighter weight, lower power models can function similarly to dedicated reading devices.
- Touch environment makes navigation easier than conventional use of keyboard and mouse or touch pad in certain contexts such as image manipulation, or mouse-oriented games.
- Digital painting and image editing is enhanced and more realistic Italian painting or sketching with a mouse.
- The ability for easier or faster entering of diagrams, mathematical notations, and symbols.
- Allows, with the proper software, universal input, independent from different keyboard localizations.
- Some users find it more natural and fun to use a stylus to click on objects rather than a mouse or touchpad, which are not directly connected to the pointer on screen.

10.3.2 Answer the following questions:

1 What is a tablet PC? 2 What are characteristic features of a tablet PC? 3 What types of tablets have you got acquainted with? 4 What is the most popular form of tablet PC? 5 What are booklets equipped with? 6 Where are they used? 7 How do slates manage to operate without keyboards? 8 What features of other tablets do hybrids include? 9 What

are the main advantages of tablets over traditional notebooks? 10 Have tablets any disadvantages in comparison with notebooks, to your mind? Name some of them, if any.

10.3.3 Translate the phrases paying attention to verbals and the ways of their translation:

the needed functionality; a product announced in 2001; tablets folding like a book; booklets equipped with multi-touched screen; pen writing recognition capabilities; computers resembling writing slates; a dedicated keyboard; touching an on-screen keyboard; using fingertips; to ensure long life by resisting heat and vibration damage; an attached keyboard; a joint called a rotating hinge; the screen to rotate through 180; the screen to provide a flat writing surface; hybrids share the features of the slate and convertible by using a detachable keyboard; a keyboard operates in a similar fashion to a convertible when attached; hybrids are not to be confused with slate models; detachable keyboards do not rotate to allow the tablet to rest on it; dedicated reading devices; mouse-oriented games; digital painting and image editing; the ability for faster entering of diagrams; users find it fun to use a stylus to click on objects; touchpad not directly connected to the pointer on screen.

10.3.4 Add nouns (from texts A, B, C) to the given adjectives and put them in comparative and superlative degrees and translate them:

fast, easy, high, light, popular, general, low, typical, active, wide, traditional, large, similar, old, feasible, possible, new, available, usual, complex, bulky, cheap, expensive, difficult, free, extreme, powerful, rapid, economical, remote, full, early, recent, capable, distinct, energy-efficient, modem, few; good, bad, little, far, many.

10.3.6 Translate the texts into English:

I

Типы портативных компьютеров – современные портативные компьютеры можно условно разделить на несколько типов: ноутбук, планшетный ПК, ультрапортативный ПК, нетбук.

Ноутбук (notebook) – это переносной персональный компьютер, имеющий клавиатуру, экран, устройство позиционирования и работающий от аккумулятора. По конструкции ноутбуки выполнены в виде раскладной книги. На рынке можно встретить большое разнообразие ноутбуков, от сверхлегких и компактных моделей, которые можно постоянно носить с собой, до тяжелых и громоздких, которые приходят на смену настольным ПК.

Нетбук (netbook) – ультрапортативный ноутбук, предназначенный в основном для просмотра веб-страниц и других несложных задач (например, для работы с офисными приложениями).

II

Планшетный ПК (tablet PC) – в эту категорию мы относим как «классические» планшетники – мобильные компьютеры, имеющие сенсорный экран, но не имеющие клавиатуры, так и ноутбуки-трансформеры (планшетные ноутбуки), у которых есть и клавиатура, и поворотный сенсорный экран. С помощью сенсорного экрана и стилуса вы можете полностью управлять работой операционной системы. Основное преимущество планшетника – возможность комфортно работать с ним, держа его в руках, тогда как для работы с ноутбуком потребуется стол или другая твердая поверхность.

III

Ультрапортативные ПК (UMPC – Ultra-Mobile PC) занимают промежуточное положение между карманными портативными компьютерами (КПК) и ноутбуками. Они оснащаются чувствительным экраном, что делает их похожими на планшетники. УППК обычно комплектуются процессорами с низким энергопотреблением, твердотельным диском, что позволяет уменьшить вес до 400-800 г и увеличить время работы до нескольких часов.

Устройство позиционирования выполняет ту же функцию, что и мышка в настольном ПК. Существуют два типа таких устройств – это Touchpad и Pointstick.

IV

Тачпад представляет собой специальную чувствительную панель размером 5-6 см. Панель может отслеживать как движение пальца, так и нажатие (щелчок), которое эквивалентно нажатию на кнопку мыши. Тачпад имеют практически все ноутбуки.

Пойнтстик представляет собой миниатюрный джойстик, который расположен на клавиатуре между клавиш. Отклоняя мини-джойстик влево или вправо, вы можете управлять курсором. Преимуществом использования пойнтстика состоит в том, что вам не нужно отрывать руки от клавиатуры, чтобы перевести курсор в другую часть экрана.

V

Устройство для чтения флеш-карт кардридер.

Большинство современных ноутбуков имеет встроенный кардридер (Flesh Card Reader), который позволяет считывать и записывать информацию на флеш-карты. Слоты для установки карт памяти обычно расположены слева и справа на корпусе ноутбука. Устройство для чтения флеш-карт может пригодиться тем, у кого есть цифровой фотоаппарат или MP3-плеер с картами памяти.

С помощью адаптера беспроводной связи Wi-Fi ПК можно подключать к беспроводной сети. При наличии уже работающей беспроводной сети для подключения компьютера не требуется прокладывать дополнительный кабель. Если в компьютере поддержка Wi-Fi отсутствует, то всегда можно купить отдельный Wi-Fi-адаптер.

10.4 Portable Computers versus Desktops

10.4.1 Read text D and speak about the distinguishing features of laptops and desktop PCs, their advantages and disadvantages :

The basic components of laptops are similar in function to their desk top counterparts, but are miniaturized, adapted to mobile use, and designed for low power consumption. Because of the additional requirements, laptop components are usually of inferior performance compared to similarly priced desktop parts. Furthermore, the design bounds on power, size, and cooling of laptops limit the maximum performance of laptop parts compared to that of desktop components.

The following list summarizes the differences and distinguishing features of laptop components in comparison to desktop personal computer parts. Laptop motherboards are highly model specific, and do not conform to a desktop form factor. Unlike a desktop board that usually has several slots for expansion cards (3 to 7 are common), a board for a small highly integrated laptop may have no expansion slots at all, with all the functionality implemented on the motherboard itself; the only expansion possible in this case is via an external port such as USB. Other boards may have one or more standard, such as Express Card, or proprietary expansion slots. Several other functions (storage controllers, networking, sound card and external ports) are implemented on the motherboard.

Laptop CPUs have advanced power saving features and produce less heat than desktop processors, but are not as powerful. There is a wide range of CPUs designed for laptops available. Some laptops have removable CPUs, although support by the motherboard may be restricted to the specific models. In other laptops the CPU is soldered on them other board and is non-replaceable.

Memory (RAM) – SO-DIMM memory modules that are usually found in laptops are about half the size of desktop DIMMs. They may be accessible from the bottom of the laptop for ease of upgrading, or placed in locations not intended for user replacement such as between the keyboard and the motherboard.

Expansion cards – A PC Card or Express Card bay for expansion card sis often present on laptops to allow adding and removing functionality, even when the laptop is powered on: some subsystems (such as Ethernet, Wi-Fi,or a cellular modem) can be implemented as replaceable internal expansion cards, usually accessible under an access cover on the bottom of the laptop.

Power supply – Laptops are typically powered by an internal rechargeable battery that is charged using an external power supply. The power supply can charge the battery and power the laptop simultaneously. The battery being fully charged, the laptop continues to run on AC power. The charger adds about 400 grams to the overall “transport weight” of the notebook.

Advantages of portable computers

Portability is usually the first feature mentioned in any comparison of laptops versus desktop PCs. Portability means that a laptop can be used in many places – not only at home and at the office, but also during commuting and flights, in coffee shops, in lecture halls and libraries, at clients' location or at a meeting room, etc. The portability feature offers several distinct advantages:

Productivity – using a laptop in places where a desktop PC can't be used, and at times that would otherwise be wasted.

Immediacy – carrying a laptop means having instant access to various information, personal and work files. Immediacy allows better collaboration between coworkers or students, as a laptop can be flipped open to present a problem or a solution anytime, anywhere.

Up-to-date information – If a person has more than one desktop PC, a problem of synchronization arises: changes made on one computer are not automatically propagated to the others. There are ways to resolve this problem, including physical transfer of updated files using synchronization software over the Internet. However, using a single laptop at both locations avoids the problem entirely, as the files exist in a single location and are always up-to-date.

Size – Laptops are smaller than desktop PCs. This is beneficial when space is at a premium, for example in small apartments and student dorms. When not in use, a laptop can be closed and put away.

Low power consumption – Laptops are several times more power-efficient than desktops. A typical laptop uses 20-90 W, compared to 100-800 W for desktops. This could be particularly beneficial for businesses which run hundreds of personal computers and homes.

Battery – a charged laptop can continue to be used in case of a power outage and is not affected by short power interruptions and blackouts.

A desktop PC needs a UPS to handle short interruptions, blackouts, and spikes; achieving on-battery time of more than 20-30 minutes for a desktop PC requires a large and expensive UPS.

All-in-one – designed to be portable, laptops have everything integrated in to the chassis. For desktops (excluding all-in-ones) this is divided into the desktop, keyboard, mouse, display, and optional peripherals such as speakers.

Disadvantages of portable computers

Compared to desktop PCs, laptops have disadvantages in the following fields:

Performance. The upper limits of performance of laptops remain much lower than the highest-end desktops (especially “workstation class” machines with two processor sockets), and “bleeding-edge” features usually appear first in desktops and only then, as the underlying technology matures, are adapted to laptops.

Laptops processors can be disadvantaged when dealing with higher-end database, mathematics, engineering, financial software, virtualization, etc.

Also, the top-of-the-line mobile graphics processors (GPUs) are significantly behind the top-of-the-line desktop GPUs to a greater degree than the processors, which limits the utility of laptops for high-end 3D gaming and scientific visualization applications.

Upgradeability of laptops is very limited compared to desktops, which are thoroughly standardized. In general, hard drives and memory can be upgraded easily. Optical drives and internal expansion cards may be upgraded if they follow an industry standard, but all other internal components, including the motherboard, CPU, and graphics, are not always intended to be upgradeable. The reasons for limited upgradeability are both technical and economic.

Durability. Due to their portability, laptops are subjected to more wear and physical damage than desktops. Components such as screen hinges, latches, power jacks, and power cords deteriorate gradually due to ordinary use. They say that a laptop is three times more likely to break during the first year of use than a desktop. Battery life of laptops is limited; the capacity drops with time, necessitating an eventual replacement after a few years. The battery is often easily replaceable, and one may replace it on purpose with a higher-end model to achieve better battery life.

10.4.2 Answer the following questions:

1 What unites PCs and desktops? 2 What limits the maximum performance of laptop parts? 3 How is functionality implemented on laptop motherboard? 4 What kind of CPU are PCs provided? 5 Compare PCs and desktops memory. 6 How are PCs and desktops supplied with power? 7 What are the main advantages of portable computers over desktops? 8 Speak about batteries used in PCs and desktops and power consumption by them. 9 What disadvantages do portable computers have compared to desktops? 10 How can one achieve better battery life?

10.4.3 Analyze verbals in the given phrases and translate them.

Laptop components adapted to mobile use and designed for low power consumption; distinguishing features; a PC card is present on laptops to allow adding and removing functionality; laptops powered by an internal battery charged by using an external power supply; laptops can be used in many places; using a laptop at times that would otherwise be wasted; a student doing his homework; a laptop can be flipped open to present a problem; there are ways to resolve the problem, including physical transfer of updated files; when not in use a laptop can be closed and put away; a charged laptop can continue to be used; designed to be portable; compared to desktop PCs, laptops have some disadvantages; laptops processors can be disadvantaged when dealing with higher-end database; other components, including the motherboard, CPU, and graphics, are not always intended to be upgradeable; a laptop is three times more likely to break than a desktop; the capacity drops with time, necessitating an eventual replacement after a few years; one may replace the battery to achieve better battery life.

10.4.4 Make as many derivatives as possible to the following words using suffixes and prefixes. Translate the words:

Example: to connect – to disconnect, connection, connected, connecting, connector, etc.

To consume, to add, to require, to perform, to differ, to process, to produce, to replace, to present, to power, to compare, to signify, to change, to convert, to calculate, to improve, to communicate, to manage, to compute, access, science, simple.

10.4.5 Find in the text words or groups of words opposite in their meaning to the words given below:

to subtract, to appear, to stand, to prohibit, to find, to open, to improve, to rise, to charge, to downgrade;

expensive, late, slow, difficult, external, big, light, unlike, compatible, low, far, worse, complex, superior, minimum, soft;

before, over, ahead, less, many.

10.4.6 Open the brackets and put the verbs in the necessary form of a verbal:

In (to compute) an image scanner – often (to abbreviate) to just scanner – is (to know) to be a device that optically scans images, (to print) texts, (to handwrite), or objects, (to convert) them to a digital image. Common examples (to found) in offices are variations of the desktop (or flatbed) scanner where the document is (to place) on a glass window for (to scan). The first image scanner (to develop) for use with a computer was a drum scanner. Hand-held scanners where the device is moved by hand, have (to evolve) from text (to scan) “wands” to 3D scanners (to utilize) for industrial design, reverse engineering, test and measurement, gaming and others.

Modern scanners typically use a charge-coupled device (CCD), older drum scanners (to apply) a photo multiplier tube as the image sensor. A rotary scanner (to use) for high-speed document (to scan) is another type of drum scanner (to use) a CCD instead of a photo multiplier. Other types of scanners are planetary scanners (to take) photographs of books and documents, and 3D scanners for (to produce) three-dimensional models of objects.

Another category of scanner is digital camera scanners (to base) on the concept of reprographic camera. While still (to have) disadvantages (to compare) to traditional scanners (such as distortion, reflections, shadows, low contrast), digital cameras offer advantages such as speed, portability and gentle (to digitize) of thick documents without (to damage) the book spine.

10.4.7 Translate text in written form

Spam

Email spam, also known as junk email, is unsolicited bulk messages sent through email. The use of spam has been growing in popularity since the early 1990s and is a problem faced by most email users. Recipients of spam often have had their email addresses obtained by spambots, which are automated programs that crawl the internet looking for email addresses. Spammers use spambots to create email distribution lists. A spammer typically sends an email to millions of email addresses, with the expectation that only a small number will respond or interact with the message.

The term spam is derived from a famous Monty Python sketch in which there are many repetitive iterations of the Hormel canned meat product. While the term spam was reportedly first used to refer to unwanted email as early as 1978, it gained more widespread currency in the early 1990s, as internet access became more common outside of academic and research circles.

Types of spam

Email spam comes in various forms, the most popular being to promote outright scams or marginally legitimate business schemes. Spam typically is used to promote access to inexpensive pharmaceutical drugs, weight loss programs, online degrees, job opportunities and online gambling.

Spam is commonly used to conduct email fraud. The advance-fee scam is a well-known example – a user receives an email with an offer that purportedly results in a reward. The fraudster presents a story where upfront monetary assistance is needed from the victim in order for the fraudster to acquire a much larger sum of money, which they would then share. Once the victim makes the payment, the fraudster will invent further fees, or stop responding.

Fraudulent spam also comes in the form of phishing emails, which are emails disguised as official communication from banks, online payment processors or any other organizations a user may trust. Phishing emails typically direct recipients to a fake version of the organization's website, where the user is prompted to enter personal information, such as login and credit card details.

Users should avoid opening spam emails and never respond to them or click on links in the messages. Spam email may also deliver other types of malware through file attachments or scripts, or contain links to websites hosting malware.

Spamming techniques

Botnets allows spammers to use command-and-control servers, or C&C servers, to both harvest email addresses and distribute spam.

Snowshoe spam is the technique of using a wide range of IP addresses and email addresses with neutral reputations to distribute spam widely.

Another method spammers use is blank email spam. This involves sending email with an empty message body and subject line. The technique could be used in a directory harvest, an attack against an email server that seeks to validate email addresses for a distribution list by identifying invalid bounced addresses. In this type of attack, the spammer does not need to enter text into the email. In other instances, seemingly blank emails may hide certain viruses and worms that can be spread through HTML code embedded in the email.

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