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# PHILOSOPHICAL PROBLEMS OF SCIENTIFIC COGNITION

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The study guide within the framework of the stated discipline briefly and in an accessible form introduces the features of the philosophical understanding of scientific knowledge, its structure, forms, ways of combining philosophical methodology and scientific methods of researching the object of knowledge; problems of the dynamics of natural science in social- and methodological dimensions, regularities, features of the modern stage are highlighted.

Recommended for master's and postgraduate students of engineering majors studying the course "Philosophical problems of scientific knowledge" or the course "Philosophy of science".

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## INTRODUCTION

Philosophical training of higher education applicants of the first educational level of higher education "bachelor" continues at the second (educational and scientific) level of higher education "master". Since the master's level of higher education is aimed at training specialists mainly in the field of research work, the discipline "Philosophical problems of scientific knowledge" is introduced into the teaching program. At the same time, what is important, the understanding of philosophy in the social- and cultural dimension refers this discipline to the cycle of social- and humanitarian master's training, which gives scientists the opportunity to make their own scientific discoveries and to form the mentality of the highest world models.

But in the sphere of higher education, we have problems that somewhat reduce the effectiveness of teaching and implementation of the results of the discipline "Philosophical problems of scientific knowledge". Therefore, it is worth paying attention to their solution. Short:

1. A problem to which little attention is paid: it is quite common for students of higher education to have a prior belief that these disciplines are unnecessary. This especially applies to master's students - because the basic philosophy that is taught to bachelors does not emphasize the need for its connection with specific sciences (especially with those specialized for this higher education institution) - in the worldview, anthropocentric, axiological, ethical aspects of classical philosophy, purely scientific issues is somewhat imperceptible. And bachelors often get the impression that philosophy is completely separate from science. And if in the future, in the master's degree, the administration of the university transfers "Philosophical problems of scientific knowledge" to the list of selective ones, it is difficult to talk about the "fate" of the discipline, the trust in its arguments and the benefits of implementing its provisions.

2.The problem, which is clearly visible in educational and educational literature: there is no ambiguity in the understanding of the content of two related disciplines - "Philosophical problems of scientific knowledge" (for master's students) and "Philosophy of science" (for graduate students). However, when the provisions of the Bologna system were introduced in 2003, sufficient clarity of instruction was observed: the master's discipline "Philosophical problems of scientific knowledge" (the study ends with a test) was introduced as propaedeutics to the discipline "Philosophy of science" (the study ends with an exam), which has long been read for graduate students. Such an instruction is already clear enough: let's say, we should start studying the history of the discipline "Philosophy of Science" from the time of the appearance of science itself - somewhere from the 27th century, and not from antiquity, as now. Until now, we can only talk about the relationship between philosophy and individual, somewhat episodic, pre-scientific ways of rational understanding of reality, therefore, this historical period is logically considered within the framework of master's course propaedeutics. The in-depth relationship between philosophy and fundamental sciences cannot be the subject of the special course "Philosophical problems of scientific knowledge", but only "Philosophy of science". Therefore, this section in the master's special course should be covered only as propaedeutics. There are other problems that reduce validity, that is, the degree of adequacy of the methodology, methods and other research tools to the tasks for which they were created. A clear demarcation of the content of these disciplines and its refinement can ensure sufficiently high validity and, as a result, the effectiveness of their implementation. It is rather difficult to comprehensively investigate this problem within the framework of the training manual, but we took some points into account when writing.

In general, the discipline "Philosophical problems of scientific knowledge" is based on knowledge of philosophy, primarily on such sections as epistemology, ontology, axiology, methodology; it ensures the formation of the outlook position of the future scientist, equips him with philosophical foundations and the methodology of scientific knowledge, ensures the qualified conduct of scientific research and the writing of scientific papers.

The course includes lectures, seminars and independent work. Studying the course ends with an exam.

# Section I. Philosophical and methodological foundations of scientific knowledge.

## Topic I. Philosophy and science.

### 1.1. Worldview, philosophy, scientific picture of the world

Worldview is a synthetic and very complex entity. It primarily includes a certain worldview, a general picture of natural and social phenomena. Along with the scientific worldview, there are also non-scientific forms of it, for example, religious or mythological.

The worldview also includes a certain attitude towards the world, which includes cognitive (epistemological) attitude, axiological (from the point of view of the system of values and evaluations), moral, legal, as well as practical-activity. Related to this is the understanding of a person's place in society, his relationship to other people and society as a whole, duties towards society, etc. Worldview also includes some social attitude related to understanding the meaning of life, life ideals , the goals of society and the means of achieving them. At the level of large social systems, this attitude is associated with long-term programs and plans of social and economic development, large-scale goals in domestic and international politics.

Worldview should be understood not only as a set of certain knowledge, but also as a complex of beliefs that are in the content of practical activities, and even in human behavior in various difficult and even critical situations. The latter allows better conclusions to be drawn about a person's true worldview than the knowledge he has learned or verbal assurances.

Thus, the worldview as a complex formation is very complex in its structure and is determined by many aspects of social life: the development of science, material production, social relations, the social structure of society, the development of the education system, the activities of mass media, state policy, existing traditions, the development of democracy . in society and other factors. From this it is clear that no science, no matter how important and significant it is, cannot create a complete synthetic worldview, but can only participate in its formation.

Natural sciences are most involved in creating a scientific picture of the world - which determines the content of world understanding in the structure of worldview. This picture is a collection of the most important achievements of science, principles and explanations that provide a holistic understanding of the world. It includes the most fundamental true knowledge about the world, tested and confirmed by practice and observation. It should not include all the true information obtained by science, since a lot of narrowly specific knowledge is not directly included in the scientific picture of the world. The scientific picture of the world is not just a set of fundamental knowledge, but a complete conceptual system that provides an integrated scientific view of nature and society. It differs from theory by a combination of abstract theoretical knowledge and visual representations, model images. Rational philosophy makes a significant contribution to the general scientific picture of the world through the development of the foundation of the entire worldview, general methodology and theory of knowledge of science. There is an inextricable relationship between these parties. Each principle and law that reflects objective truth has at the same time methodological significance for science, if it is used as a guide in cognition, for the transition from the known to the unknown, as well as for the correct understanding of the empirical facts of science. Therefore, not only the theory of knowledge, epistemology, but also the teachings of rational materialist philosophy about matter, its attributes, principles and laws are of methodological importance for science.

In modern literature on the logic and methodology of science, the concept of *paradigm*, used by T. Kuhn in the book "The Structure of Scientific Revolutions", has become widespread. Sometimes this concept converges with the concept of a scientific picture of the world. In this context, one sometimes talks about the style of scientific thinking of the era. In what relationship are these concepts?

The term "paradigm" in the sense that T. Kuhn used it meant the most common *stereotypes* in a certain era in the understanding of various natural phenomena, as well as in approaches to their explanation. As a result of scientific revolutions, paradigms changed. This concept is much narrower in its content than the scientific picture of the world, and in the best case it can mean some fragment of it, and only if the paradigm expressed the correct generally accepted understanding of some natural phenomena. But in the history of science, there were also incorrect paradigms, such as, for example, the geocentric view of the world or the teleological concept of nature, which were rejected because of their anti-scientific nature. One should not exaggerate the general significance and stereotyping of approaches to understanding nature in the past. Such general significance does not exist in the present time, and even more so it did not exist in the past when the means of exchange of scientific information were very underdeveloped, when there was no system of reference and information service, and contacts between scientists of different countries were episodic. At the same time, there was a fierce struggle between elemental-materialist and religious-idealist concepts, between Catholics and Protestants within the limits of religious ideology. In the field of science, there was a very sharp polemic between the Cartesians and the followers of Newton, and both of these groups were opposed by H. Leibniz and his followers, who in turn were criticized by the French materialists, and the views of the latter were unacceptable to I. Schelling and H. Hegel, etc. d. Therefore, if we consider not just one school that developed around an outstanding scientist, but the entire collection of scientists in different countries of Europe (not to mention other continents) during a relatively long period of history of 50-100 years, any single and universally recognized paradigm in the understanding of the world then did not exist. The mechanical picture of the world was adamantly rejected by theologians and idealistic philosophers, the idea of evolution in biology and the natural origin of man was anathema from the pulpits of the church. If there was unity of opinion, it was within the framework of one direction or school, where this unity was ensured by the highest authority of the spiritual leader and generator of ideas of this direction.

In the concepts of T. Kuhn, P. Feyerabend, N. Lakatos and other representatives of postpositivism, scientific revolutions are interpreted as the destruction of old paradigms, their rejection and replacement by new ones, which, in turn, will also be rejected over time, etc. Relativity is excessively exaggerated scientific knowledge leading to relativism. False concepts are indeed rejected during scientific revolutions, but true knowledge, tested and confirmed practically, is preserved in a refined form in subsequent theories. The development of the scientific picture of the world is subject to the principle of continuity of objective truths. The edifice of science is not destroyed every time as a result of a scientific revolution, but is completed consistently, obeying the dialectic of the relative and the absolute in knowledge.

If we consider further the concept of the style of thinking in a certain era, it turns out that it is also not equivalent to the concept of a scientific picture of the world. Thinking style expresses a certain worldview and methodological approach to understanding the world and explaining empirical facts. It includes applied research methods, some epistemological or social attitude in cognition. It can be conservative and orthodox, or, on the contrary, critical and revolutionary. But there is also a conformist, accommodative or eclectic style of thinking, which, unfortunately, is quite common. The concept of thinking style includes a significant psychological component, which in the scientific picture of the world is reduced to a minimum so that the truth is as objective as possible. In addition, as follows from what was said above about paradigms, there was no single style of thinking in the communities of scientists.

Rational materialistic philosophy and methodology are able to give modern science a solid philosophical foundation, integrating in its worldview and methodology the most important results of those own philosophical studies that were produced by the natural sciences on the basis of their historical experience of knowing the world. With this, it determines the ways to the methodological integration of modern science.

## 1.2. Philosophy and science are common and different

As a special form of spiritual production, philosophy first arose approximately 4-3 thousand years ago in Egypt, Babylon, India, and China. It takes on a more systematized and scientific appearance in Greece about 2,500 years ago.

Philosophy has many definitions. For Heraclitus, it is identified with disinterested knowledge of the essence of things. According to Aristotle, it studies higher, universal causes and principles of being, essential. According to Damascene, philosophy is knowledge and teaching based on knowledge. During the Middle Ages, philosophy was identified with worldly wisdom, which radiates the "natural light of reason." Hegel called philosophy the science of the mind, which understands itself. According to Marxism, philosophy is the science of the most general laws of the development of nature, society, and thinking.

Despite the somewhat vague definition of the subject of philosophy, it is still possible to outline the range of problems that only it investigates. First of all, it is the search for the "unity in diversity", that is, the search for the primary basis, the substance of the universe, on which all the superficial, sensual diversity of the world is based. Secondly, the search for answers to the so-called eternal questions, i.e. key worldview problems. Thirdly, it is a synthesis of the data of specific sciences into a single, universal scientific picture of the world. Fourth, it is the discovery and study of universal, universal laws of development of nature, society and thinking.

In its content, philosophy is pluralistic and dialogic, because it allows the confrontation of logical arguments in the free search for truth. This leads to a certain unsystematic nature of its subject. Therefore, the search for the foundations for its systematization has been underway for a long time. Even in ancient times, philosophers came to the conclusion about the bipolarity of the world, that is, its division into spirit and matter. The question of the relationship between these two primary elements - spirit and matter or man and the world - became logical. It is called the main question of philosophy and has two sides: ontological and epistemological. The ontological side is formulated as follows: what is primary: spirit or matter? Depending on the answer, philosophers divided into two camps - materialism and idealism.

The epistemological side of the main question of philosophy is formulated as follows: is the world knowable? (or: do human thoughts about the world correspond to this world itself?). Depending on the answer, philosophers again divided into two camps - agnosticism, which denies the principle of knowing the world, and the concept, which considers the world to be fundamentally knowable. There is also a concept that tries to reconcile the polar positions of materialism and idealism. She believes that the world is based on two equal, parallel substances - matter and spirit. It is called dualism.

This way philosophy in structurally form is getting more clear and systematized.

Philosophical pluralism, which implies the internal orderliness of philosophy, manifests itself not only in its division into materialism and idealism. Already ancient philosophy was acquiring its composition and included three sections - logic as a science of cognition, physics as a science of nature, ethics as a science of man. These three parts still make up the core of philosophy today. The structure of modern philosophy is as follows: ontology as a doctrine about the objective fundamentals of the world; epistemology (theory of knowledge); social philosophy; philosophical anthropology; praxeology (philosophical understanding of practice); axiology (the doctrine of values); philosophy of religion, ethics, aesthetics and, finally, the history of philosophy (unlike other spheres of human activity, philosophy is possible only in the process of self-referral, self-remembering).

The question about the relationship between philosophy and science can be rephrased as: is philosophy science? The answer to this question should precede the presentation of the main material of the special course, as it will contribute to the formation of an atmosphere of trust in the methodological arguments of philosophy. Especially since in historical and philosophical literature we observe a "fan" of answer options - from: "philosophy and science have nothing in common" to "philosophy is part of science" (intermediate options: "science is part of philosophy"; "philosophy is a synonym of science "). The very definitions (formed in the cognitive aspect) testify to the complexity of the task and the multifaceted nature of the answers:

Philosophy- this is the unity of all possible forms of knowledge of the world, which are systematized within the framework of the highest form of rational worldview - for man to achieve his perfection.

Science- this is a methodically organized rational form of knowledge of the world, based on the logic of interrelated empirically confirmed laws, thus allowing a person to create more perfect values.

The results of comparisons of definitions add even more questions, for example: indeed, definitions fix the commonality of ratio in philosophy and science - but the commonality of values? Practice shows that it is not necessary. We have examples when worldview guidelines turned out to be more important than the values declared by science.

Similar problematic situations have a significant psychological and pedagogical aspect, which is important: at seminar classes, you can arrange discussions on their solution, forming critical thinking in students of higher education, which is so necessary for a researcher.

Let's do analyze the comparison results of definitions, highlighting the obvious. Ratio is indeed a powerful unifying factor between philosophy and science. However, as at first glance, it is not the only one. All other factors rather indicate differences between them. Let's highlight the main points:

- by primacy of origin: philosophy is the oldest form of rational knowledge, and full-fledged science arose in the 27th century. in Western Europe;
- by status: philosophy is an "axial center"; only around him all forms of social consciousness are formed, including scientific knowledge;

- by object of knowledge: the object of knowledge of philosophy is universal, it is the endless and eternal, material and spiritual world, the world in all its manifestations - including man. The object of knowledge (rather, research) of science is a part of objective reality, the presence of which is subject to empirical verification, verification by sensory experience;
- by the scope of knowledge: the subject of research of specific sciences are "narrow" laws within their object (physics, biology, medicine, etc.); the subject of knowledge of philosophy is universal laws. However, not all philosophical schools operate (and even recognize) the expression law of philosophy. However, it cannot be denied that only philosophy plunges into the ultimate conceptual bases of being, forming unifying stable cause-and-effect relationships, which can be called in different ways - basis, principles, concepts, categories - or laws. As an example, let's take the dialectical unity (according to Hegel's expression) of the philosophical categories of quantity and quality. The dialectical unity of these categories is a reflection of the objective interrelationship of the stable and the variable, which is preserved in any single object, everyday or scientific. That is, it permeates the entire "vertical" of existence - from everyday life through science to the depths of the universe;
- by features of philosophical or scientific knowledge. We emphasize the step-by-step process of obtaining scientific knowledge. At some point, specific sciences inevitably come to the "denial" of previous forms of their knowledge; it is "removed" by further knowledge within the framework of a new paradigm. As an example, we can take the deepening of knowledge about the nature of space - from Euclid's geometry, according to which parallel lines never intersect, through Riemann's geometry (parallel lines intersect in the infinity of space), Lobachevsky's geometry (parallel lines diverge in the infinity of space) to Einstein's theory of relativity (parallel lines reduces or dilutes space itself due to its curvature, i.e. deformation by matter). It is significant that today's stage of deepening knowledge about space is already "preparing" for the transition to the next stage of knowledge, since the theory of relativity itself indicates the limits of its application in the analysis

of black holes and the singularity of space-time. Unlike science, various forms of philosophical knowledge are always unified in their content (although there is a certain approximation here), because they penetrate into the conceptual unity of the universe, which is reflected in the universal concepts of philosophy itself.

And anyway, with sufficiently significant differences, the relationship between philosophy and science is practically necessary, natural. At the research level of the development of science (which is accompanied by a master's and postgraduate program in philosophy), there is practically no hope of achieving significant, strategic success without taking into account philosophical provisions and guidelines. Every scientific research (especially a breakthrough discovery) in fundamental sciences will be possible and effective only against the extremely broad background of philosophical methodological principles (and the effectiveness of research in applied sciences relies on philosophical methodology indirectly, through fundamental sciences). Paradoxically, this is explained by the same points with which we previously marked the differences between philosophy and science. Let's highlight the main thing.

Philosophy, as the oldest form of rational cognition of the world, long before the appearance of classical science, and already with its help composed a conditional universal network of cause-and-effect chains, which objectively, albeit extremely generalized, "covered" almost completely the object of knowledge - the infinite and the eternal world and man in it. This "covering" is not artificial, it is based on philosophical discoveries, which, for example, at the level of common sense sound like this: "Everything in the world is interconnected with everything", "Everything penetrates everything and everything is separated from everything - at the same time", etc. . The task of rational philosophy is to transform the apparent chaos of relationships into a system through the formation of conceptual markers - categories, principles, theories, laws - first philosophical, then, against their background - ethical (good-evil), aesthetic (beautiful-ugly), religious ( faith-sacredness), scientific (truth-reliability). The basic category of the science of truth, on the one hand, should be based on the "network" of philosophical causal chains, and on the other hand, should permeate all principles, concepts, theories and laws of science. Thus, no serious scientific study can ignore the dialectic of quantity, quality, measure, leap - a natural interrelationship of philosophical categories with which even everyday life is calculated (a popular warning is: "Medicine is separated from poison only by quantity"). You can despise the "meaningless" principle "Everything is interconnected", but only at the cost of leveling the smallest chances for effective scientific research.

However, it should not be ignored that the concept of the *interrelationship* does not mean one-sided dependence of science on philosophy, but interdependence. And she is. If philosophy, in turn, did not rely on rational, empirically confirmed arguments, it would quickly lose respect for its propositions, as it would become somewhat fantastic. Therefore, being a discipline purely theoretical, philosophy takes empirically confirmed arguments (concepts, laws, etc.) from the sciences, first of all, from the fundamental sciences. The process of deepening the philosophical understanding of the category of *matter* under the influence of scientific progress can serve as an illustration. Democritus' statement about the atomic basis of matter (atoms are the smallest in size, indivisible particles of matter that move in absolutely empty space) was "clarified" by philosophy after 2 thousand years already under the influence of science - classical mechanics - equating matter and mass. After 300 years, explosive changes in the development of natural sciences led philosophy to another, also "explosive" clarification, according to which matter, for example, is even language, which has neither mass nor spatial dimensions.

Thus, the success of the methodological and prognostic functions of philosophy is also explained by relying on scientific argumentation, - of course, in combination with the capabilities of the universal rational apparatus of philosophy itself, and philosophy itself acquires scientific features.

There is another one of a reason why philosophy is partly related to science. In the history of philosophy, previous forms of knowledge about reality are compared with current ones. A comparison of past and present forms of knowledge allows it to be periodically adjusted and predictions made about future forms. Those forecasts that are justified acquire the force of law, that is, they become scientific and philosophical knowledge.

As a result of the above, the following conclusion can also be drawn: raising the question of whether philosophy is a science is illegitimate. It would be more correct to say that scientificity can be an essential characteristic of philosophy without turning it into one of the varieties of scientific knowledge.

### 1.3. "Philosophical problems of scientific knowledge" - general characteristic of the discipline

Basing on the previous provisions, it is possible to assert the unique role of science and technology as a means of organizing life and managing the future. In this case, the need to form a separate, complex knowledge with extremely general analytical capabilities, which is able to systematize the unique achievements of science in common laws, categories and principles, taking into account both historical and socio-cultural contexts, is understandable in this case. Such a branch of new philosophical knowledge became the philosophy of science (which includes the discipline "Philosophical problems of scientific knowledge" as its propaedeutics). Philosophy of science as a separate discipline was gradually formed at the end of the 20th century in Europe and North America. Over time, her range of interests has expanded significantly - today it includes:

- analysis of the relationship between natural and social sciences;
- analysis of the relationship between science and other ways of spiritual development of the world;
- analysis of the ratio of facts and their assessment in science;
- analysis of the relationship between ontological, epistemological, epistemological, ethical and general cultural aspects of the development of science;
- analysis of the ratio of classical, non-classical and post-classical stages of the development of science;
- analysis of the relationship between the categories of science (primarily

the categories of *objective truth*, *truth*) with the categories of postmodern philosophy – *posttruth, interpretation,* simulacrum;

- analysis of the relationship between science and politics in solving global problems, primarily environmental problems;
- analysis of the ratio of everyday and theoretical knowledge;
- analysis of the ratio of "emotional" and scientific intelligence in the spiritual development of the world;
- analysis of the ratio of philosophical-methodological and narrowly professional aspects of each branch of science in order to optimize specific scientific research;
- analysis of the ratio of methodology of principles: methodological unity of specific scientific research in rational philosophy and pluralism ("deconstruction" - Derrida J.) in the philosophy of postmodernism;
- analysis of the relationship between the language of science and everyday language;
- analysis of the relationship between logic and scientific rationality.

We see that the philosophy of science today is a necessary answer to the various requests of society: 1) what is the nature of reality - objective or subjective; 2) does religion contain objective truth and vice versa - can intuition and generally everything irrational be a part of science; 3) whether scientifically effective experiments (for example in experimental medicine), etc., could be morally justified.

In general, philosophy of science tries to understand and figure out the place of science in modern civilization, in its multiple relations with everyday life, ethics, politics, and religion. Such discipline is extremely necessary for humanity and there is nothing to replace it. The philosophy of science plays a unifying, general cultural role and does not allow scientists to limit themselves to a narrowly professional vision of processes and phenomena, as this significantly reduces the effectiveness of their research and increases the impact of negative manifestations in ethical and ecological aspects.

The previous analysis shows that the philosophy of science conventionally has three constituent parts, which means three groups of problems.

The first group belonges those related to the very existence and function of science in society. This is a question about the essence of science, its value, its place in the structure of human activity, its specificity against the background of other knowledge, such as everyday life, religion, myth, etc. The answers to these questions are important, because they lead to an understanding of science as a special field spiritual activity.

The second component of the philosophy of science combines problems related to understanding the interaction and mutual influence of scientific and philosophical knowledge. This is a question of the relationship between the truths of science and philosophy, scientific and human values, ethics of science, prospects for the development of science, etc.

Problems within science itself are solved by the third component of the philosophy of science. This is an analysis of specific cognitive structures, methods, procedures and operations used in scientific research; these are problems of methodology, methods, forms, values, criteria, regularities, etc.

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Thus, the philosophy of science is a holistic discipline aimed both at the development of philosophy itself and at the generalization of research into scientific and intellectual processes, at the study of the structure of scientific knowledge, ways and methods of scientific knowledge, methods. on reasoning and knowledge development. In other words, the philosophy of science is a section of philosophy, the subject of which is a holistic and valuable consideration of science as a separate field of human activity in all its manifestations.

Conclusion. The philosophy of science strives to:

- formation of the ontological foundations of science;

- formation of epistemological foundations of scientific activity;
- development of logical and methodological foundations of science;
- creation of a model of scientific rationality;
- publications of problems of scientific creativity;
- revealing the possibilities of using a systemic approach and synergy in scientific work;
- analysis of the language of science;
- development of scientific classification;
- analysis of the relationship between science and society;
- discussion of problems of scientific efficiency;
- consideration of relations between science and religion, science and politics;
- consideration of the etymological basis of science;
- study of the problems of ethics and aesthetics of science;
- development of strategic theories of science

In the current philosophy of science, there are other concepts that offer their own models of the development of science and philosophical analysis of cognitive activity. Modern Western philosophers (XX-XXI centuries) understand the problems of the philosophy of science somewhat vaguely. The place of philosophy in science is assessed differently: some see it as a kind of philosophy based only on the results and methods of science (R. Carnap, M. Bunge); others see in it either an intermediate link between natural and humanitarian knowledge (F. Frank), or a branch of methodological analysis of scientific knowledge (P. Feyerabend). Critical rationalism (K. Popper) considers the philosophy of science as a methodology and focuses on various methods of scientific research: substantiation, idealization, falsification, analysis of meaningful prerequisites of knowledge. A. Whitehead strives to build a single picture of the world, a complete picture of the world structure.

The understanding of the key problems of the philosophy of science also changed over time. In the first third of the 20th century, the focus was on the following problems:

- construction of a complete (comprehensive) scientific picture of the world;
- research on the context of determinism and causality;
- research of dynamic and statistical regularities;
- analysis of the structural elements of scientific research: the relationship between logic and intuition, induction and deduction; analysis and synthesis; discovery and reasoning; theory and fact.

In the second third of the 20th century, the following problems became dominant:

- analysis of empirical science;
- study of methods - verification, falsification, deductive-nomological explanation;
- justification of the paradigmatic model of scientific knowledge, scientific research program, problems of thematic analysis of science.

In the last third of the 20th century and at the beginning of the 21st century, an expanded understanding of scientific rationality is being discussed, the competition of various models of the development of science is intensifying, and attempts are being made to restore the logic of scientific research. Scientific criteria, methodological criteria and the conceptual apparatus of the post-classical stage of the development of science acquire a new meaning. This is a detailed study of the history of science, which focuses on the social determination of scientific knowledge, the humanization of science.

By studying these problems, the philosophy of science acquires normative significance and performs the functions of a methodology of knowledge. Therefore, the study of philosophical and methodological problems of science is of great practical importance for scientists of specific branches of science.\

### 1.4. Questions and tests for self-testing of knowledge

1. How are the concepts of worldview and philosophy related?
2. How are the concepts of philosophy and methodology related?

3. How are the concepts of epistemology and epistemology related?

4. How are the concepts of scientific picture of the world-paradigm related?

5. How are the concepts of philosophy and science related?

6. How are the concepts of logic and scientific rationality related?

5. What does the expression "style of scientific thinking" mean?

6. Does philosophy have laws?

7. The categorical apparatus of the philosophy of science does not include:

a) epistemology;

b) ontology;

c) epistemology;

d) logic;

e) methodology.

8. Knowledge is:

a) these are abilities, skills, and knowledge-based skills;

b) these are objective laws that are expressed in terms of language;

c) a set of concepts, theoretical constructions and ideas;

d) the process of interaction between consciousness and reality, as a result of which images, intellectual models and constructions of reality are built in consciousness;

e) data, information about the world;

9. The driving force of cognition is:

a) practice;

b) activity of the subject;

c) contradiction of knowledge and unknown

# Topic II. Scientific knowledge and its features

## 2.1. Science as a social phenomenon. The structure of science and its functions. Principles of classification of sciences.

Science is a product of world development and has a global character. Ideally, science is a whole, since its highest goal is to study the world in all its fullness. But in practice, science is a complex multifaceted phenomenon that can be viewed in different aspects. In the cultural aspect, it is a component of culture, a form of social consciousness that ensures the progress of society, its continuous development.

In the logical and epistemological aspect, it is a system of knowledge consisting only of experimentally proven data about the world and conclusions obtained on the basis of the laws of logic.

In the praxeological aspect, it is an extremely important productive force of society, a special activity that transforms not only material production, but also the spiritual sphere.

In the social aspect, it is a special social institution in which conditions are formed for the collection, analysis, processing and use of various information about the world. Science has a complex organizational structure, relies on a special material base and a system of special methods of acquiring knowledge.

Science performs the following functions: descriptive, systematizing, explanatory, praxeological, prognostic, worldview.

Structure of science: scientific idea, problem, hypothesis, concept, theory, law, etc.

- - an idea is a form of scientific knowledge in which true knowledge of reality is combined with the subjective goal of its transformation, not only what is, but what is proper is fixed;
- - problem is a form of scientific knowledge in which a contradiction is recorded between knowledge about people's needs and ignorance of the means of their realization. Therefore, the problem is the unity of two elements: knowledge of ignorance and anticipation of the possibility of discovery;

- hypothesis is a scientific assumption in which one of the possible solutions to the problem is fixed, the truth of which has not yet been proven;

- concept is a form of scientific knowledge in the form of a system of theoretical propositions regarding the object of research, which are united by a certain idea. The basic content of the theory is substantiated in the scientific concept;

- theory is the most complete and adequate form of scientific knowledge, a system of reliable, deep and specific knowledge about the object of knowledge. It has a clear logical structure and provides a holistic view of the regularities and essential characteristics of the object of knowledge. It is objective in content, subjective in form and has two functions - explanation and prediction. Science is a collection of theories;

- law is a relationship, a connection between the entities of the object of knowledge, which is objective in content, necessary, repeated, general, internal, esential.

The criteria of scientificity that distinguish science from other forms of knowledge are: objectivity, systematicity, practical focus, orientation to predictions, strict evidentiality, reasonableness and reliability of results.

*Principles of classification of sciences*. Such an interdisciplinary discipline as scientific studies deals with the principles of classification of sciences. It studies the regularities of the development of science, the structure and dynamics of scientific knowledge, its interaction with other types of human activity in the spheres of material and spiritual life, as well as with various social institutions. Scientific studies is a complete methodological and social system of knowledge about science. It covers all existing sciences in their relationship and in connection with practice, taking into account economic, social, political, cultural conditions of functioning and development.

The more than thousand-year history of the development of science highlights a number of patterns and trends in its own development. Science at each stage accumulates scientific achievements in a concentrated form, and each fact is included in the general fund, not crossed out by further achievements of knowledge, but only rethought and clarified. Science at every moment of time acts as a total expression of humanity's progress in knowledge of the world.

The inherent heredity of science reduces it to a single channel of gradual development and the irreversibility of its character, ensures the functioning of science as a special type of common social memory of mankind, which theoretically uses the previous experience of knowing reality and mastering its laws.

The main tasks of science are:

- - study of the laws and trends of the development of science;
- -analysis of science interactions;
- -forecast of the development of science;
- -problems of scientific knowledge and scientific creativity;
- - organization of science and management of its development.

One of the main tasks of scientific studies is the development of a classification of sciences, which determines the place of each science in the general system of scientific knowledge and the relationship of all sciences. The classification of sciences performs the function of grouping scientific knowledge into certain systems, which contributes to the unification of science and its overall efficiency, including through international cooperation and the growth of development rates.

Modern science divides the sciences into: natural, technical, social and humanitarian. This classification is based on the specific features of the study of objects of reality - material and spiritual - by various sciences. Classification also records (reflects) regular relationships between objects, determines their place and main properties in a complete system, is a means of saving and searching for information.

## 2.2. Logical and epistemological foundations of science.

The logical foundations of the theory are the rules and laws of logic by which derivatives are derived from the original terms and sentences. Terms are derived from terms, and propositions are derived from propositions in accordance with the rules of definition and the rules of derivation. The logical foundations of the theory are also called the logic of the theory. The logical foundations of the theory represent a means of logical systematization of the theory (a means of bringing its terms and propositions into a logical system). We will analyze the logical foundations of the theory in more detail,

Each natural science has different kinds of problems - its own (internal), logical, methodological, philosophical, etc. Philosophical problem of natural science theory is a problem, the solution of which is significantly based on philosophical foundations. Examples of philosophical problems of natural theories are: the problem of the theory's relation to reality; the problem of dialectical regularities of the reflection of reality by theories; the problem of methods and criteria for evaluating the truth of theories; the problem of interrelationship of introduction and exclusion of abstractions; the problem of analyzing the content and form of the theory; etc. These problems require the use of philosophical foundations for their solution.

For example, in mathematics there are many logical problems, that is, problems whose solution is based on logic. The task of deriving theorems from axioms is a logical problem, because only the laws and rules of formal logic are essential for its solution. It is very important to note that there are many logical systems. These include, for example, various "classical" logics, constructive logics, multi-valued logics.

Questions arise: which of the logics can be the logical basis of this mathematical theory? Is a single (let's say, classical) logic suitable for this purpose? Or maybe any logic is suitable here? What are the methods of testing the suitability of a particular logic to be the logical basis of a mathematical theory?

Many methodological problems of mathematics are directly formulated in these questions. This is due to the fact that the solution of such problems requires such methods, provisions and techniques that belong to the methodology of mathematics and a specific set of which forms the methodological foundations of this mathematical theory. However, the following questions inevitably arise: why do we assert the suitability of this or that logic as the basis of some mathematical theory? Why do we use this criterion of the validity of the theory and what is its practical meaning? These questions themselves express the philosophical problems of mathematics, because their solution is based not only on the logical, but also on the philosophical and methodological basis of mathematical theory. If such a basis is chosen incorrectly, then the solution to specific problems will also be incorrect.

Since the philosophical and methodological foundations of mathematical theory are the most fundamental, their choice is determined by the practical and theoretical significance of the entire philosophical system that is chosen as a whole. In this sense, materialist rational philosophy is truly scientific and the most correct methodological basis of mathematics, because it has received practical approval by all natural and social sciences and ultimately by social-historical practice. From the very connection of logical problems with methodological ones, and methodological problems with philosophical ones, the meaning of the role played by the correct solution of philosophical problems of natural science emerges.

It is well known that, even knowing one's own and logical basis of the theory, it is still possible not to obtain the necessary proposal. There are two reasons for that. First, in addition to the logic of the proof, it is necessary to master the methodology of its search, which belongs to the heuristic methods of mathematics (its heuristic foundations). Practically, heuristic methods have not been described and developed with any precision (with the exception of some approaches to this problem proposed, for example, by D. Poya). In other words, even if a proposition is proved, its proof cannot always be practically implemented. Therefore, a heuristic problem arises here, the solution of which is significantly based not on the logical and methodological, but on the heuristic foundations of mathematics. Second, this proposition may turn out to be unproven. Then the task arises to show that it is not deduced from the theory's own grounds by means of its logical grounds.

It is clear in advance that it is impossible to solve this problem based only on logic, because even a large number of unsuccessful attempts to derive this proposition from an axiom will not prove anything. Solving such a problem relies on the methodological basis of mathematics. In particular, it can be obtained by building a model in which the theory's own grounds would be true, and the investigated proposition would be false.

The methodology of mathematics says that if this situation really takes place, then our proposal is not derived from the theory's own grounds and therefore does not belong to this theory (otherwise the theory would be semantically contradictory, because it would derive both true and false propositions). But at the same time, the question may arise: why should the theory not be semantically contradictory? This problem is essentially no longer logical, but philosophical and methodological.

At first glance, it seems that it is possible to solve this problem, relying only on the condition of the deductive value of the theory. After all, in a controversial theory, any proposition that can be formulated in the language of the theory is derived using the rules of ordinary classical logic. However, it is possible to reconstruct the logic of the theory so that it does not have a rule according to which any proposition of the language of the theory follows from the contradiction. By the way, practically in ordinary thinking this rule is not used. As a result, a theory that contains a contradiction will be deductively non-trivial, that is, it has deductive value. But in this case, in explaining the inadmissibility of conflicting theories, one should turn to its more fundamental basis, namely, the philosophical and methodological one.

Such a basis is the principle of the relationship between objective reality and knowledge. According to this principle, the theory should be an adequate reflection of objective reality. It is important for us to emphasize that, as practice confirms, in objective reality objects cannot have any property and at the same time not have it. Therefore, the statement about the presence of any property in the object cannot be compatible with the statement about the absence of this property in the same object at the same time. Since one of these statements is true and the other is false, they cannot belong to a theory at the same time.

### 2.3. Relationship between science and religion: philosophical analysis.

Science and religion are fundamental branches of culture, types of worldview that interact with each other.

For a long time, the understanding of the relationship between science and religion was reduced to the fact that they were interpreted as diametrically opposed phenomena. The problem of the relationship between faith and knowledge was solved within the framework of the assessment of religion as an inferior type of knowledge, which is doomed to disappear with the development of science. Later, religion and scientific knowledge began to be considered as different but legitimate forms of human spiritual activity. Moreover, they can contribute to each other in achieving their goals, since they have something in common:

- science, first of all, is not absolutely objective knowledge, which brings it closer to religion; secondly, humanity, despite significant scientific progress, is still not given a generalized perception of the integrity of the universe. Therefore, scientific knowledge and religion are interconnected, penetrate each other;

- in science, there are structures that derive knowledge, taken for granted, as axioms of certain scientific theories. And religious systems are also some generalizations based on argumentation and evidence (examples are the dispute between Friedman and Einstein; Ecclesiastes: "I know what the Almighty has done! It is impossible to add to it and there is no [possibility] to take away from it"; 5th century BC: Job - "The earth on which bread grows is hollowed out inside as if by fire; Zoar - the sphericity of the Earth, etc.

Differences between science and religion:

- science does not proceed from absolute truths, it is characterized by a critical view of what is happening in its field; the pressure of new evidence may lead to revision of former provisions;

- the source of faith is not objective reality, but superpersonal revelation, knowledge given to man from above; religion answers marginal questions related to absolute ideals.

The vitality of religion is also facilitated by its constant speculation on the difficulties of science. From the point of view of rational philosophy, the emergence of both science and religion is connected with the emergence of abstract, theoretical thinking and the possibility of separating thought from reality - because only then can a general concept separate from its class of objects and turn into a separate, even fantastic image. This image is constantly reinforced by the contradictory, problematic nature of the cognitive process, which enables constant theological speculation on unsolved problems of science and, as a result, constant reproduction of religious ideas.

### 2.4. Rational and irrational: essence and relationship in scientific knowledge. Intuition as a type of irrational in science.

The topic of the rationality of knowledge belongs to the category of "eternal" in philosophy. It has its roots in ancient philosophy, but it becomes a direct, clear object of analysis as an epistemological category only in modern times.

Over time, the very understanding of rationality (ratio, reasonableness) is refined. Today, rationality can be defined by the following concepts: expediency, systematicity, consistency, orderliness, and logic of judgments, actions, and behavior. At the same time, we draw attention to the fact that the traditional identification of rationality and logic has not withstood the test of time. It became obvious that rationality and logic do not completely coincide, as it was believed for quite a long time in the European tradition. The laws of logic are subject to both rational, substantively erroneous, and even nonsensical judgments.

It is important to emphasize the essential feature of scientific rationality, because today, together with the dominance of postmodern philosophy, rational arguments are often taken to be the conclusions of "emotional intelligence", value preferences, and everyday conclusions of the level of common sense. All this significantly reduces the level of reliability of rational conclusions. Sensory-emotional, worldview, and value are "non-scientific" components of consciousness and distort the scientist's cognitive activity. An essential feature of rational argumentation is proof. Argument can be defined "as establishing the truth of a thesis using logical means by means of arguments whose truth is already determined in advance" (Wikipedia). The main types of argument are: obvious propositions, facts, axioms, laws of science, defined concepts (terms). The form of such argumentation should be deductive reasoning.

Irrational generally means that which is beyond reason, illogical, or unintellectual; traditionally irrational is incompatible with rational thinking or may even contradict it. However, the modern understanding of rationality has led to a new interpretation of its relationship with irrationality. The result of this process was the identification of irrational components of knowledge, primarily intuitive and logical, which led to conclusions about the complexity of ideas about the structure and functions of natural and social-humanitarian knowledge. With such an approach, the irrational somewhat gets rid of its negative evaluation, because it is understood as intuitive, which captures the unconscious aspects of the mind itself with imagination and feeling. At the same time, it is present as a necessary creative component of cognitive activity and subsequently, as a rule, acquires the features and status of rational knowledge.

*Intuition as a type of irrational in science*. A scientist's intuition, which is an irrational function of the psyche, occupies a special place in scientific and cognitive activity. According to Freud, it is based on the personal or collective unconscious. Intuition as a "premonition" as an "involuntary event that depends on various internal and external circumstances" was also studied by Z. Freud's follower K. Jung, but he did not provide a perfect theory of intuition.

As an irrational beginning of knowledge, intuition performs a "starting" function in the creative movement of the mind, which puts forward new ideas or instantly "grabs" the truth not as a result of observing the laws of logic or axioms from existing knowledge, but spontaneously, unconsciously, only after checking the guess with logic.

The reasoning of the German philosopher Georg Hegel deserves attention. Reason can sometimes, according to Hegel, "bring the definition of reason to nothing" and, breaking the old one, create a new logic. Accordingly, on this path, overcoming dogmatism and formalism, strictly following the established rules and norms, the mind goes through the stages of movement from the existing rational through the irrational-intuitive to the new rational. As a specific cognitive process, intuition synthesizes the sensory-visual and the abstract- and conceptual.

Intuition has a contradictory nature: the suddenness of enlightenment has a reason - it is the previous conscious work and willful efforts of the scientist to concentrate information on a topic that interests him extremely. When the optimal volume is reached, the information is "arranged" in a way to solve the problem, but in an unusual way - the ready-made solution precedes the logical path of its formation. And it is impossible to trace how it was achieved. When trying to do this, the "alloy" of concepts and images "disintegrates" into a chaos of separate ideas and concepts, and it ceases to be coherent and understandable.

A sudden "discovery of the truth" presupposes a preliminary "incubation", according to A. Poincaré, a period of unconscious activity during which a new idea matures. In this period, free from the rigid discipline of thinking, the most diverse combinations of ideas, images and concepts are born, the attribution of which occurs implicitly, based on the researcher's definition of the goals of thinking and as a result of some external impulse, far from the circumstances of the study. The path leading to a guess-enlightenment remains unconscious, hidden from the researcher, the finished result suddenly enters the sphere of consciousness, and it is impossible to trace how it was achieved. The search for methods of studying and describing the "mechanism" of intuition continues.

In science, propositions that do not have a clear definition and arguments, that are ambiguous, allow for different interpretations, and are often based not on logical foundations, but on common sense conclusions, are sometimes called intuitive. Belief in the "self-evidentness" of the starting propositions, which is often expressed by the words "it is obvious", "it is easy to see", "it follows from this", can hide an unconscious error or mislead. Self-evidentness is sensory-emotional, psychological authenticity, and therefore it cannot serve as a criterion of truth. It is often based on familiar ideas, behind which rich essential connections and properties become imperceptible. Such hidden errors are quite dangerous in scientific research. And therefore, any research, both in the natural sciences and in the humanities, involves the detection of such hidden errors and the achievement of a "higher class of accuracy." At the same time, it is impossible to identify all intuitive points and exclude them, fully defining and formalizing all knowledge. Intuition (although it does not have "probative force") replaces knowledge that is still being formed; it serves as a kind of reference point that "anticipates" possible paths of research. For example, sensory intuition or the ability for visual spatial imagination in geometry after the discovery of non-Euclidean geometries, was proven to be false, although it is heuristically and didactically effective.

Thus, cognition has irrational elements, which are many and variously represented by various kinds of unconscious, implicit, intuitive. They significantly complement and enrich the rational nature of scientific knowledge. Creating difficulties for the construction of accurate knowledge, they simultaneously include in knowledge an active creative beginning and the personal abilities of the researcher himself.

In general, the modern understanding of rationality recognizes the following basic principles: critical analysis of both cognitive and value prerequisites, the possibility of overcoming them (open rationality); dialogicity, recognition of the legitimacy of other positions; the unity of rational and irrational forms in science and culture; trust in the subject who knows, acts freely and responsibly, critically rethinks the results of his knowledge and attitude to the world.

### 2.5. The relationship between facts and theory: a philosophical analysis

Content analysis of the concept of fact is relevant not only in the philosophy of science, but also in everyday life. The reason for this is a big difference in its understanding.

It is traditionally considered that: a fact is reliable information that corresponds to the truth or the truth (in everyday life, the concepts of *truth* and the *try* are often equated): a fact can only be a reliable, reliable, substantiated objective truth - one's own judgment, a subjective assessment in the definition the fact is considered inadmissible; such phenomena as false or alternative facts cannot exist in principle.

This is how factual information and one's own opinion about it are used, for example, in journalism. There is a rule that the news should be based only on facts, without the personal opinion of the author, that is, the journalist. News should be balanced and free from personal judgments. Newspapers, as a rule, publish news and their own (subjective) opinions about them on different pages. This is done to separate fact-based news from personal judgments and evaluations of the news.

We think further. Since the main purpose of expressing one's opinion or judgment is to convince others, arguments are used to support it, as statements that are based on facts. This means that one's own opinion is supported by data based on facts. But this contradicts the initial data of this analysis.

A cognitive dissonance arises, as it is customary to say today. On the one hand, your judgment is not a fact. On the other hand, it is generally accepted that it should be based on facts! Otherwise, the reasons why it should be listened to or taken into account disappear.

Against the background of these generally accepted, but rather superficial ideas about the facts, we will analyze their deep understanding with the help of the philosophy of science. And first of all, we will show that a self-sufficient objective fact does not exist in principle.

The philosophy of science claims that the relationship between facts and theory is one of the main problems of knowledge and theory of science. Theory is systematically organized, integrated knowledge, aimed primarily at explaining facts, real phenomena, events united in a certain object of knowledge. It is she who determines and outlines the understanding of the fact as a real objective phenomenon, its representation and fixation in language forms. This means that fact and reliable objective information can differ from each other, and sometimes differ significantly. The structure of the fact is also secondary, with admixtures of subjectivity - because it also comes directly from the existing scientific theory. Therefore, in knowledge, a fact always has a theoretical interpretation (and in everyday life – interpretation by various own judgments). The recognition that the same fact is inevitably accompanied by different – even opposite – interpretations in everyday life and in science gave birth to the idea of developing a specific factual language.

Scientific theory unites and systematizes a certain set of factual data using the procedures of abstraction, analysis, and synthesis, which is carried out by describing (and explaining) these data. Fixing the results of the description requires the development of language tools that ensure the accuracy of its content. It is always incomplete, approximate, since the translation into the language of description, for example, of any regular movement, dynamic dependence will have errors. One thing is real movement, the other is its reflection, the result of fixation in linguistic form.

A fact is a single phenomenon that has a completely private, specific character. A fact is understood not only as an event or phenomenon, but also as a statement about this event or phenomenon. Scientific knowledge exists in the form of statements, sentences.

Components of the fact:

• perceptive (from "perception" - perception) - sensory image. The empirical basis includes sensory data that is reproducible and intersubjective. Science has little interest in what has been directly observed by consciousness or cannot be observed again;

• linguistic – statements that formulate a fact;

• material and practical – a set of devices, means and actions with them, which are used to establish a fact.

Views on the relationship between theory and fact: a) naive: facts are outside the theory and do not depend on it; b) modern: theory is an indirect generalization of facts. Empirical research is carried out on the basis of theory. Fact - theoretically interpreted data. That is, the fact itself does not exist, it is always theoretically loaded. The dependence of fact on theory and paradigm was analyzed by Kuhn in his work "The Structure of Scientific Revolutions".

The function of the fact is to test the theory. Non-empirical criteria are also involved in this (simplicity, coherence (mutual consistency and consistency with the theory itself and other theories), aesthetics). The same facts, depending on the interpretation, can confirm different scientific theories. Even a proven theory is also involved in the interpretation of facts. So the facts are ultimately interpreted in the light of the theory being tested.

### 2.6. Fundamentalist concept of truth. Truth, truth, delusion.

Truth is one of the central philosophers of the theory of knowledge.

In modern philosophy, the following concepts of truth are most clearly distinguished:

- classical or correspondent concept of truth: truth is the correspondence of knowledge to objective reality;
- coherent concept of truth assumes that truth is the ability of knowledge to self-consistency;
- conventionalist concept of truth: truth is the result of an agreement between scientists, the result of a convention;
- pragmatic concept equates truth and utility, i.e. considers truth as utility. efficiency of knowledge.

Achieving truth is the ultimate goal of knowledge. The classic definition of truth given by Aristotle is the correspondence of our knowledge about objective reality to this reality itself. Its opposite concept is false opinion, delusion. Briefly consider the main characteristics of truth: objectivity, absoluteness, relativity, concreteness.

Each truth is subjective in form and objective in content. Objective truth is such a content of knowledge that does not depend either on a single person or on humanity as a whole.

Absolute truth means complete identity of knowledge with its object, exhaustive knowledge about the object, which can never be refuted. Such knowledge is only theoretically possible. But since not only knowledge is developing, but also its object - the surrounding world, humanity can only get closer to the absolute truth.

Relative truth is knowledge that is correct in principle, but does not fully reflect reality, therefore it must be constantly deepened and clarified in the direction of absolute truth. Every relative truth has an element of absolute truth.

From the analysis of the dialectic of absolute and relative truth, its next characteristic - concreteness - is deduced. This is a sign according to which the truth of this or that statement depends on the conditions, place and time, as well as only in a certain defined theoretical system, frame of reference, etc. Abstract posing the question about the truth of a particular statement leads to an uncertain decision. Yes, to the question "In general, is rain good or bad?" - we will get the answer - "both useful and harmful". Therefore, there is no abstract truth, the truth is always concrete.

In communication, truth is often equated with truth, so it is important to emphasize the specifics of each concept. Truth is knowledge of a concrete, factual episode of reality. It is incomplete, because only a fragment is revealed to a person, and not the whole. This is subjective information that only claims to be reliable, the antonym of the word "delusion". Truth is the only reliable information that absolutely accurately reflects the object. There is only one truth, and the truth is only the point of view of a specific person on any event or fact. You can try to dispute any truth, but the truth cannot be doubted.

How can we be sure whether our knowledge is correct or incorrect? This is ultimately achieved through practice. Practice is diverse - from everyday life experience to complex scientific experiments. It is the basis of knowledge, its driving force, the objective criterion of truth. If the object during its use manifests itself as expected, it means that our ideas about it are true. The practice develops historically. Therefore, it acts both as an absolute and as a relative criterion of truth.

### 2.7. Questions and tests for self-testing of knowledge

1. What is meant by science?
2. What are the functions of science?
3. Name and comment on the structural components of science.
4. What does science study?

5. How are rationality and logic related?

6. What philosophical problems of natural theories do you know?

7. Common and different in science and religion.

8. Rational and irrational: essence and relationship.

9. The role of intuition in scientific knowledge.

10. How are theory and fact related?

11. What concepts of truth do you know?

12. Is there knowledge without elements of delusion?

13. How are truth and truth related?

14. What is fasting truth

15. What are the criteria for the truth of knowledge?

16. Which concept of truth asserts that "that which is useful is true":

a) correspondent;

b) pragmatic;

c) coherent;

d) conventional;

e) there is no correct answer.

17. Science is not:

a) social institution;

b) form of social consciousness;

c) component of culture;

d) productive power of society;

e) a subjective-linguistic phenomenon.

18. The main criterion for the truth of knowledge:

a) practice;

b) observation;

c) intelligence;

d) intuition;

e) another truth.

# III. The methodology of scientific research as the core of the philosophy of science.

## 3.1. The concept of methodology is a general characteristic

Progress in all areas of human activity, its complications and scope raise the problem of developing a system of principles that determine the approach, nature and assessment of the creative activity of collectives and individuals, raise questions about the criteria of social significance and acceptability of scientific and technical achievements, about the growth of the social responsibility of a person - a creator new It is about a deeper and broader understanding of the methodology of knowledge and transformation of the world, which meets the requirements of today. The formed idea about methodology as a teaching about structure, logical organization, methods and means of activity needs further clarification.

The term "methodology" has several definitions: 1) it is metascientific knowledge, aimed not at the object of knowledge, but at the methods of its research, at the methods by which this knowledge is obtained; 2) it is a teaching about the system of principles, forms and methods of research activity - in science, politics, art, etc.; 3) teaching about this system, common theory of the method, theory in the research process; 4) it is a form of organization of effective activity of the researcher.

In other words, methodology is understood as a set of diverse ways, methods, and techniques that are used in the process of scientific knowledge to achieve a predetermined goal. The philosophy of science states that such a goal in scientific knowledge is to obtain objective, true scientific knowledge or a scientific theory and its logical justification, confirmed by a certain effect in an experiment or observation, etc. In addition, the methodology, based on the theoretical and sociocultural experience of mankind, develops the general principles of creating new cognitive tools and sets the task of finding out how the obtained scientific knowledge about reality is transformed into a method of further knowledge of this activity, and to reveal the effectiveness of the application of new methods.

The emergence of methodological research is connected with the development of science. In other words, the methodology is formed within the limits of philosophical knowledge during the analysis of the formation of science - initially the science of the classical period, which made the entire world, its laws, properties of various spheres the object of knowledge.

Rapid development of science in the 20th century. discovered new features and characteristics of scientific knowledge, which for many years were the subject of research by logicians, methodologists and philosophers of science. Among the new phenomena in methodological knowledge, the intensive filling of the abyss between the natural and social (the idea of the noosphere, sociobiology, ecology), between being and mind, between natural and artificial, living and non-living (cybernetics, artificial intelligence, related fields of scientific knowledge) ), between formal and meaningful, theoretical and practical (design and forecasting, planning and programming, construction and modeling), etc.

In modern philosophy, the problems of methodology and method are discussed in the philosophy of science, synergistics, phenomenology, etc. Modern methodology avoids extreme evaluations of methodological programs or absolutization of any of them, which happened in the past. Many researchers justify methodological pluralism (that is, different methodological approaches, for example, the concept of pluralism of methods by P. Feyerabend). In modern science, a multi-level concept of methodological theory has developed. In general, modern methodology includes many different approaches from the past, it also focuses on the principle of social conditioning of knowledge, sociocultural determinism (that is, science is considered as a subsystem of culture), subjective parameters of the cognitive process, reductionism, etc. are taken into account.

In accordance with these changes in the characteristics of scientific knowledge and its interaction with practice, the methodology of science as a special branch of philosophy also developed, the nature of methodological research changed, the subject of the methodology of science was expanded and qualitatively enriched, the structure and functions of knowledge were complicated according to the guidelines of the methodology.

As its own object of knowledge, methodology has regularities of scientific and cognitive activity, its forms and methods. At the same time, the history of science is a history of struggle, competition, changes in various methodological teachings. Historically, philosophy became the first form of "comprehension" of the results of the development of science, the methods and forms of knowledge applied by it. It is philosophy that acts as an "intellectual exploration", a trend, a general direction of scientific research, paths leading to the truth, thanks to the application of general methods of cognition. This tendency is manifested later, even in our time.

Nowadays, the methodology of science is one of the most developed methodological theories, an independent theoretical discipline. The methodology of science is aimed at obtaining new knowledge, with the help of cognitive procedures it investigates the optimal connection between the scientific result and the means of its achievement. And if new scientific knowledge is obtained spontaneously, then the methodology of science subjects scientific knowledge to analysis, which reflects not only objects, but also ways of knowing them. The modern methodology of science examines scientific knowledge, its structure, organization, various models, forms of systematization of knowledge and adequate interpretation of the objective content of knowledge. Methodological studies cover all types and forms of scientific knowledge, carry out analysis and develop general principles of its justification. Particularly interesting for the methodology of science are scientific theories, their emergence, development, relation to objective reality and other forms of knowledge. The purpose of the methodology of science is also the development of standards, drafting prescriptions and guidelines for scientific thinking and research, focusing attention on the foundations of science, which can be transformed into means of increasing the effectiveness of scientific theory. The need for such research arises when a situation of choice arises in science, for the implementation of which the available theoretical and empirical material is insufficient.

Based on the fact that the implementation of any activity on the basis of a certain method involves a conscious correlation of the way of action of subjects with the real situation and an assessment of its effectiveness, there is a desire to automate, formalize these methods to a pure technique, formal rationalization, in order to accelerate their formation.

The methodology of cognition has a three-level structure (that is, methodological analysis has three levels of application):

1. Specific science is the technical techniques, regulations, theories of one or another discipline - that is, a system of specific methods and techniques used to solve special, "narrow" research tasks. For example, methods of labeled atoms in biochemistry, conditioned reflexes in physiology, questionnaires in sociology, etc. They are often called methods.

2. General scientific (or interdisciplinary) is a teaching about the principles, methods and forms of knowledge that function in many sciences. For example, methods of empirical research: observation, measurement, experiment; empirical and theoretical methods: analysis and synthesis, induction and deduction, analogy, etc. Having appeared as techniques used by specific researchers, they are then used by scientists in other fields of knowledge, that is, they receive wide scientific and cultural-historical approval, which gives them the status of general scientific methods.

3. Philosophical (fundamental) methodology is the highest level of methodology, its core. In the philosophical analysis of a specific scientific object of research, the entire content complex of philosophy is used as regulators of scientific knowledge as needed - ideas, propositions, categories (for example, necessity-accident, phenomenon-essence, cause-effect, etc.), principles of laws. Within these considerations, a certain methodological mobility and complementarity of content can be observed in many philosophical positions, laws, principles and categories. For example, the principle of concreteness of truth has the methodological force of a social law. Or: the relationship between the categories "quantity-quality-measure" acquired a holistic character in Hegel in the form of a dialectic of the categories of

quantity and quality; in Marxism - the law of qualitative and quantitative changes; in modern philosophy - microsystems "quantity-quality-measure".

The methodology of science, based on philosophical principles and laws, historically arose and develops on the basis of epistemology, epistemology and logic, and in recent years also history, sociology of science, social psychology, cultural studies and linguistics.

The basis of philosophy as a core in the methodology of scientific knowledge is the unity of general scientific and philosophical levels of knowledge. Its purpose is to identify and understand the driving forces, prerequisites, grounds and regularities of the growth and functioning of scientific knowledge and cognitive activity, to organize design and construction activities. It makes it possible to systematize the entire volume of scientific knowledge and thereby create conditions for the development of further effective directions of research, which, in turn, makes it possible to ensure the use of achievements in the development of science for practical purposes.

### 3.2. Philosophical principles and functions of the methodology of scientific knowledge.

The methodology of science, based on philosophical principles and laws, historically arose and develops on the basis of epistemology, epistemology and logic, and in recent years also history, sociology of science, social psychology, cultural studies and linguistics.

Basic philosophical principles of the methodology of scientific knowledge: principle

- objectivity;
- determinism;
- reflection;
- dialectics;
- systematicity;

 creative activity of the subject in cognition.

Of course, all philosophical and methodological principles are of key importance in specific scientific research. For example, let's analyze the role of the principle of systematicity in scientific knowledge, since it is necessary to take it into account here. Every object of scientific research needs its application, but concrete scientists sometimes ignore this requirement. Its essence lies in the need for a comprehensive study (including philosophical and methodological) of voluminous and complex objects (which are systems), their study as a single whole, but with the coordinated functioning of all its components. Therefore, we must analyze each specific scientific activity for object research as a certain system that has a set of interconnected components, subsystems, functions, goals, and structure. That is, in the system research, the object under analysis is considered as a certain set of elements, the interrelationship of which determines the integral properties of this set. The main emphasis is placed on identifying a variety of interrelationships that take place both within the studied object and in its interaction with the external environment.

The properties of the object as a complete system are determined not only and not so much by the total properties of its individual elements or subsystems, but by the specificity of its structure, special system-forming, integrative connections of the object under study. General characteristics of the system:

-integrity;

 -structure;

 -functionality;

-interaction with the external environment;

 -hierarchy;

 -goal orientation;

 - self-organization.

Any field of scientific activity must be analyzed taking into account a systemic approach. Orientation to a systematic approach in research (structure, interrelationships of elements and phenomena, their subordination, hierarchy, functioning, development integrity, system dynamics, essence and features, factors and conditions) is justified when the task is to investigate the essence of a phenomenon, process.

Thus, the system principle makes it possible to determine the strategy of scientific research.

Scientific research in any field of science must have a methodological basis, primarily basic philosophical principles. The main philosophical principles of the methodology of scientific knowledge:

- - objectivity;
- - determinism;
- - the principle of reflection;
- - the principle of dialectics;
- - principle of systematicity;
- -the principle of creative activity of the subject in cognition.

The methodology performs the following functions:

- -determines methods of acquiring scientific knowledge that reflect dynamic processes and phenomena;
- -directs, provides for a special path on which a certain research goal is achieved;
- -ensures the comprehensiveness of obtaining information regarding the process or phenomenon being studied;
- -helps to introduce new information to the foundation of the theory of science;
- -provides clarification, enrichment, systematization of terms and concepts in science;
- -creates a system of scientific information based on objective facts and a logical-analytical tool of scientific knowledge.

Another important element of scientific knowledge - along with methodology - is the logic of scientific research, which is understood as the observance of the path strictly defined by its laws in the scientific search for truth. Scientific research requires a logical sequence of certain stages, the basis of which is rational cognition.

Thus, philosophy as a methodology provides the researcher with systematic knowledge of the most general principles and laws of the development of nature, society, and thinking, and thus allows to encompass the world in its entirety, as well as to determine the place of the researched problem among many others. Philosophy as a methodology acts here as a conditional searchlight that illuminates the scientist's path into the unknown. In a broad sense, the methodology of science is a philosophical discipline about the genesis, structure and functioning of scientific knowledge, its transformation into a cognitive toolkit, that is, into a scientific method.

### 3.3. Characteristics of the method. Classification of methods

We must agree that the topic of methods of influencing reality has always been at the center of philosophy - because philosophy, according to Damascene, is knowledge and teaching based on knowledge. However, teaching methods have always been a problem, which means they have been in the center of attention. This problem becomes especially relevant in Europe in the 17th century, when the intensive development of natural sciences and technology began. Today, methodological problems of science are considered by such currents of philosophy as critical rationalism, phenomenology, hermeneutics, structuralism, neopositivism, etc. But mainly the philosophy of science is based on materialistic rational philosophy in its modern interpretation.

It is generally accepted that a method is a system of defined rules, techniques, methods, norms of scientific knowledge and practical activity. It can be added that it is a system of requirements, principles that guide the subject in solving a specific task in a certain field of activity. In the field of scientific knowledge, this is a sequence of operations that makes it possible to find a general thing - that is, a law, a necessity in a certain area being studied.

Over time, the concept of "method" is filled with a new meaning, which includes qualitative characteristics of the subject of knowledge. And this is right, because the task of determining the most correct way to solve this or that problem is before a person - a researcher, a scientist. Spontaneous search for this path requires a lot of time and extra effort, and it does not always lead to the desired goal. We have a waste of time and effort that cannot be considered reasonable. In addition, the researcher must not only correctly formulate the problem, determine the nature of its solutions, but also predict the results of its practical implementation. And this largely depends on the ideological positions of the scientist, on his ideas, evaluations of social life. The ideological position of the scientist is a factor that significantly affects the nature and results of creative work, and in this capacity is a methodological factor.

According to the place in the application hierarchy, we will highlight the following methods:

- Philosophical - as extremely general methods used in all spheres of knowledge;
- general scientific;
- interdisciplinary (integrative, they are used in complex scientific research);
- concrete-scientific, which are involved in a specific field of scientific activity (they are also called methods).

General scientific methods, in turn, can be divided into:

- methods of empirical research;
- methods of theoretical research;
- general methods.

Among the philosophical methods, the most famous in the philosophy of science are dialectical and metaphysical.

Dialectics is an understanding of the world and a way of thinking, according to which disparate phenomena, subjects (as objects of research) are analyzed in a relationship, in an interaction that necessarily turns into a process of mutual change and development. Development is understood as a natural qualitative change, in the process of which new, necessary, capable of self-movement emerges.

Accordingly, concepts, categories and other forms of thinking must be flexible, mobile, interdependent, united in opposites, in order to correctly reflect the ever-evolving reality. Therefore, the most important principle of dialectics is historicism - consideration of the object of research in its change, development, self-movement.

The antipode of the dialectical method also penetrates the philosophy of science - it is most often called the metaphysical method. It is quite popular, widespread in everyday life, because it is the basis of so-called common sense. An essential feature of the metaphysical method is the one-sidedness of the approach to the object of research and its absolutization in the conclusions. The absolutization of one of the sides of the living process of cognition or another element of the whole, moment of activity in any of its forms inevitably leads to a distortion of the result. A metaphysician understands development as a simple, only quantitative increase or decrease, as repetition, movement in a circle, or in a straight line. Metaphysics denies the interconnectedness of processes, contradiction as a source of development. Anti-dialectical can be both a method of cognition and a method of practical activity - bureaucracy, conservatism, voluntarism.

Alternatives to the dialectical method are also sophistry, eclecticism, and negative dialectics. Sophistry is a one-sided, subjectively arbitrary method of argumentation, which, by manipulating concepts, passes off the non-essential as essential. Eclecticism is an arbitrary mechanical, unprincipled combination of arguments and positions. Negative dialectics is the absolutization of points of negation in dialectics.

At the empirical level, such methods as observation, description, measurement, experiment, and modeling are used.

At the theoretical level of scientific knowledge, the axiomatic, hypothetico-deductive method, the method of ascent from the abstract to the concrete and the unity of the logical and the historical operate.

There are also so-called "mixed" methods, that is, those that operate at both the empirical and theoretical levels of scientific research. They are also called general logical, since they are universal means of cognition and thinking. These are the following methods: analysis and synthesis, induction and deduction, abstraction, generalization, modeling, formalization, idealization.

### 3.4. Questions and tests for self-testing of knowledge

1. What methods of cognition include induction and deduction?

a) to special scientific ones;

b) to general philosophical ones;

c) to general scientific;

d) to the metaphysical;

e) to the dialectic.

2. The method of studying nature according to F. Bacon:

a) analysis;

b) synthesis;

c) induction;

d) deduction;

e) demarcation.

3. The method of cognition, according to which thought moves from the specific to the general:

a) hypothesis;

b) analysis;

c) deduction;

d) induction;

e) measurement.

4. The methodology performs the following functions:

a) determines methods of acquiring scientific knowledge;

b) provides for a special way on which a certain research goal is achieved;

c) ensures the comprehensiveness of obtaining information;

d) helps to introduce new information to the foundation of the theory of science;

e) all answers are correct;

5. Basic philosophical principles of the methodology of scientific knowledge:

a) the principle of objectivity;

b) the principle of determinism;

c) the principle of reflection;

d) the principle of dialectics;

e) all answers are correct;

6. The method of interpretation, "dialogue with the text" belongs to:

a) ontologies;

b) dialectics;

c) hermeneutics;

d) metaphysics;

e) Gnosticism.

7. The method of learning and researching the phenomena of nature and social life:

a) principle;

b) instrument;

c) method;

d) hypothesis.

# Section II. Philosophical and methodological context of natural sciences and technology

## Preface.

There has always been a close relationship between philosophy and natural science, which significantly determined the content of each of these fields of knowledge. It begins even before the ancient period of the formation of science. The primary undivided knowledge about the world and man, accumulated over many centuries of the development of the primitive-ancestral society, did not yet contain either philosophy or natural science, but was a collection of empirical information, beliefs and myths that were tirelessly passed down from generation to generation. But with the invention of writing and the development of material production, class stratification and the division of labor into mental and physical accumulation of knowledge occurred at an increasingly rapid pace. This led first to the emergence of science as a theoretical system of knowledge about the world, and then to the differentiation of sciences.

It is a very common idea that all knowledge was once concentrated within philosophy, from which other sciences later separated or "spilled off". Such marginalization of some branches of knowledge really took place, but in general, the formation of philosophy and other specific sciences in terms of their subject and theoretical content historically took place more or less simultaneously and in parallel with constant interaction and continuous exchange of concepts. Already in Ancient Greece in the V-III centuries. to n. along with the philosophical concepts of the universe and society, such sciences as astronomy, mathematics (arithmetic and geometry), geography, medicine, and history began to form.

Gradually, differentiated knowledge about the practical spheres of people's activities was accumulated: agricultural production, construction, manufacturing of various household items, the art of military operations, etc. At the same time, the objective self-determination of philosophy took place, which increasingly focused on the general problems of being and knowledge: what is the essence of the world; the world was created by God or exists forever and is material; what is the meaning of life; what are the prospects and goals of society, the future fate of humanity; Is the world knowable and what are the laws and methods of this knowledge. Different answers were given to these and similar global worldview questions in religious-idealist and materialist teachings; they are still the subject of philosophical discussions, although the progress of knowledge has provided an unambiguous scientific solution to many of these questions. Natural sciences were also periodically included in their discussions and gave their answers, which stemmed from the theoretical content of these sciences. But in the process of differentiation of sciences and a more precise definition of their subject, the field of research in each of the sciences was limited to more partial and specific questions.

In general, the formation of theoretical natural science is based on purposefully carried out experiments and observations, on a natural deterministic explanation of natural phenomena with the help of known laws of the movement of matter and active causes.

Philosophical foundations are organically included in the content of any fundamental science, determine its worldview and methodological significance. But applied sciences do not develop general problems of the worldview, which is why it borrows from philosophy through the basic fundamental sciences. True, applied sciences make a certain contribution to the development of epistemological and social philosophical problems. Much of their content is also borrowed from philosophy and the basic sciences, but many aspects are developed based on the theories and applications of applied disciplines. Technical sciences have their own specific methods of research, processing of empirical information, and forecasting of scientific and technological progress. They (as in agricultural and medical sciences) have their own socio-practical problems, forms of connection with production and social relations through the activities of research and educational institutions. All this determines the specificity of the methodological and social foundations of each applied science. The content of these sciences cannot be derived deductively from the fundamental sciences. The general does not determine the entire content of the specific, only part of it. The other part is determined by specific forms of communication with reality, the solution of practical tasks, the peculiarities of the methods used in this, as well as many other factors that influence the development of applied disciplines and scientific institutions that develop them. Taking into account what has been said allows for a deeper understanding of the complete failure of thought, which is quite common, as if only fundamental sciences provide theory, and applied sciences can only be a "kitchen" where these theories are applied to solving specific problems. There is also a deep theory in fairly developed applied sciences (technical, medical, etc.), and this also refers to their philosophical foundations.

With the development of science, there is a change in scientific theories and there is an opportunity to retrospectively analyze the concepts that have been put forward. There is an increasingly deeper explanation of the studied phenomena with the involvement of the achievements of others, in relation to theories more developed in certain aspects, which leads to the integration of knowledge. General scientific methods of research are being improved and the process of foundation of some theories with the help of other, more developed ones is being strengthened. All this leads to the emergence of new philosophical problems in the sciences with the consistent solution of many traditional problems.

# Topic I. Philosophical and methodological problems of mathematics.

## 1.1. Mathematics in the real world

The question of the direct subject of mathematics remains within the competence of mathematics itself, because mathematics itself solves the question of how and why to create mathematical objects. However, this question is closely related to the question of the subject of mathematics in real reality, which concerns the relationship of mathematics as a branch of knowledge to the real world and is therefore an epistemological problem. This problem belongs to the competence of the philosophy of mathematics, regardless of who deals with it - philosophers or mathematicians. The main method of solving it stems from the very specifics of the subject of mathematics in the real world. As mentioned, this subject is the spatial forms and quantitative relations of the real world, that is, forms and relations highlighted in a "pure" form, completely separated from the content. Based on this, the philosophy of science formulated a method of displaying quantitative relationships. It consists in the following: in order to be able to investigate these forms and relations in their pure form, it is necessary to completely separate them from their content, to leave this latter aside as something indifferent. In this connection, it is necessary to clarify how the quantitative relations (or form) of the objects of reality are actually distinguished in their pure form, that is, how they are "separated" (of course, mentally) from the content.

First, we will show the difference between quantitative relations as relations isolated in their pure form from qualitative relations or specific relations that take place between specific objects of any particular system. Then we will explain the difference between quantitative and qualitative relations using examples, and then we will dwell on the methods of extracting quantitative relations in their pure form. Yes, industrial relations exist only in society and in no other area of the real world. So, these are qualitative relations, since they depend on the specific content (qualitative specificity) of the objects between which they take place. That is, the relationship depends on the specifics of social economic systems. But the relationship of equality can exist in nature, and in society, and in thinking, generally speaking, between any objects. Therefore, this relationship does not depend on the specific content of the objects between which it takes place and is therefore a quantitative relationship.

The question arises: how to single out (in abstraction) a quantitative relationship in its pure form, that is, how to describe it so that this description depends on the specifics of the content of the objects between which these relationships exist? Let's start explaining this technique with a concrete example.

Let's imagine a certain crystal of table salt. Regarding such a crystal, it can be said that it is a system consisting of eight sodium chloride molecules and the electromagnetic interconnections that exist between them. It is clear that a specific crystal is a specific system (of qualitatively defined objects and relationships) that differs from other systems, including table salt crystals, which have a different location in time and space. It is obvious that any pair of such crystals, and therefore all these crystals as a system, can be brought into a mutually unambiguous correspondence, firstly, by comparing each molecule of one crystal with a single molecule of another crystal, and vice versa, each molecule of the second crystal - with a single molecule of the first crystal; and, secondly, by matching each electromagnetic relationship of some molecules of the first crystal with the relationship of the molecules of the second crystal, and vice versa, by matching each electromagnetic relationship of the molecules of the second crystal with the relationship of uniquely corresponding molecules of the first crystal. As a result of such a comparison, we can say that all table salt crystals are isomorphic, since they are the same in shape due to the mutually unambiguous correspondence of the systems, and what is common to all isomorphic crystals is their form isolated in pure form. Thus, the form is common to all isomorphic systems.

How to describe it in general? For example, in the language of graphs, molecules are represented by circles (vertices) of the graph, and electromagnetic interactions that exist between molecules are represented by segments (edges) of the graph. As a result, the shape of the table salt crystal is described by all known graphs representing the cube,

Let us emphasize that the shape of the analyzed crystals are specific relationships, that is, specific electromagnetic relationships of specific molecules, exactly what is common in the electromagnetic relationships of any table salt crystals when they are mutually unambiguously compared. Moreover, in this case, it is completely irrelevant that table salt crystals consist of sodium chloride molecules and have electromagnetic interconnections. Therefore, it is possible to deviate from the nature of molecules, as well as from the nature of their relationships. Then the shape selected by us will already be a cubic shape as such. And a special case of the cubic form in general will be the form of a table salt crystal.

This form, separated from the content, is the quantitative relationship of mathematics, which is studied, in particular, geometry. A quantitative relation is also a relation of types of equality. It is obvious that this relation is the general one that exists in the equality of any objects, regardless of their specific characteristics. This general applies to physical objects according to their weight, to people according to their rights, to statements according to their truth, etc. This generality does not depend on the qualitative specificity of the objects between which specific relations of equality take place. It is called an equality-type relation. It is this, and not specific equalities, that is a quantitative relation.

Thus, from the examples given, it is clear that the content of a specific system includes specific items that make up this system, and specific relationships (interconnections, interactions, etc.) that take place between these items. The form (quantitative relations) of a system is its relations, isolated in their pure form, that is, the general thing that characterizes the relations of all systems isomorphic to this system. What is common in isomorphic systems is the "pure" form." Mathematics, dealing with the quantitative relations of reality, studies reality, distracting from the content as irrelevant for its tasks, and considers only the form as essential. But the form is what is common to all isomorphic systems. Therefore, mathematics does not distinguish systems that are diverse in content, but isomorphic (identical in form). It distinguishes only systems that are not identical in shape (not isomorphic). That is why it is said that mathematics reflects reality with the accuracy of the isomorphism, that is, mathematics considers various systems with the accuracy of the isomorphism.

Examples of real-world quantitative relationships studied by mathematics are well known. These are relations of the type of equality, the relation "more", "less", geometric relations, which have already been mentioned, etc. Practice convincingly shows that prototypes of these relations exist in the real world, and this, in turn, allows with full reason to talk about the existence of the subject of mathematics in the world.

However, the above does not mean that mathematics studies only existing forms of reality. It is able to construct and possible forms. Therefore, mathematics can be defined as the science of logically possible, pure (that is, abstracted from content) forms or, what is the same, about systems of relations, since form is a system of relations.

The methods of extracting the form in its pure form are very diverse. Logical-mathematical languages are used for this. The use of graph language has already been mentioned. Along with this, the axiomatic method is essential. The idea of using the axiomatic method to highlight quantitative relations in a pure form is to describe the relations without resorting to the description of the specifics of the objects between which they take place. If this can be done using an axiomatic description of relations in a logical-mathematical language, then this task will be solved. When solving this problem, it should be remembered that the properties of quantitative relations are something common to isomorphic systems. Moreover, it should be "highlighted", deviating from the content of these systems. The result of this operation will be the conclusion that the common properties of all isomorphic systems are the general properties of their relations, which constitute the essential properties of the relations of all isomorphic concrete systems.

Thus, in the case of an equality-type relation, the properties of reflexivity, symmetry, and transitivity will be essential. An axiomatic description of the properties of reflexivity, symmetry, and transitivity in a logical-mathematical language will allow us to distinguish the relation of equality in its pure form.

From the given example, the general requirement to highlight (through description) quantitative relations in a pure form becomes quite clear. It consists in the fact that this description does not contain terms denoting specific objects of reality (specific objects, specific properties and relationships). Logical-mathematical languages satisfy such requirements. Therefore, they are used to highlight quantitative relations in their pure form.

According to the principles of rational philosophy, science, including mathematics, is a reflection of reality. This thesis is important for the philosophy of mathematics. Mathematical concepts, from the point of view of rational philosophy, arise from the real world and are connected with it. They reflect certain aspects of objective reality and are therefore its abstractions. These abstractions, however, do not mean detachment from the real world and practice.

The essence of mathematics as a cognitive science consists in the reflection of quantitative relations of reality, which are distinguished by it when studying them in their "pure" form. It is impossible to perceive these relations sensuously. They can be distinguished only with the help of abstract thinking, which uses the operations of generalization and idealization.

## 1.2. Correlation of the subjects of mathematics, logic and natural science

To solve many philosophical problems of mathematics (for example, the problems of the specificity of mathematical knowledge) it is very important to distinguish the subjects of mathematics, logic and natural sciences and to establish their relationship. To shed light on this complex and confusing issue, some clarifications are necessary.

First, it is necessary to distinguish between mathematics as a science and natural sciences (physics, biology, chemistry, etc.) (when such a difference is insignificant, mathematics, natural sciences and even mathematical logic are combined under the general term "natural sciences"). Such a distinction is based on the fact that mathematics occupies a special place among other sciences, because, investigating the forms and relationships found in nature, society, as well as in thinking, it is distracted from the content and excludes from the arguments allowed in it, observation and experiment. Therefore, it cannot be counted among natural sciences or social sciences. If the natural sciences, in fact, directly study reality, then mathematics directly studies not the objects of reality themselves, but mathematical objects that can have prototypes. The basis of any science lies in the reality it reflects. However, mathematics does not have the objects and phenomena of reality as its immediate subject, but ideal objects, which it considers hypothetically, excluding references to experience from its arguments.

Secondly, it is necessary to clarify the basis on which the subjects of mathematics, logic and natural science should be compared, because the choice of such a basis will necessarily determine a different solution to the problem. Here, the basis for distinguishing sciences is the specificity of their reflection of objective reality. This is important not only because of solving the problem of the subject of mathematics in objective reality, but also because otherwise it is difficult to separate the subjects of logic and mathematics. The fact is that both mathematics and logic distinguish the form (distracting from the content) of the studied systems in their pure form. However, the form given by mathematics is different from the form given by logic. Mathematics singles out in its pure form the form of systems of reality, from which (as well as from the content) logic deviates. Logic distinguishes the form of linguistic systems (concepts, judgments, theories, etc.), in particular mathematical ones, which are a reflection of reality.

Mathematics distinguishes systems of objective reality that have different forms (and identifies, that is, does not distinguish the content of systems that have the same form). Logic does not distinguish not only the content of systems of reality, but also their forms (which are distinguished by mathematics), if they are expressed (described) by the same relations of belonging to objects of any properties. Now it is important to note only that form as a subject of logic is not the same as form as a subject of mathematics. And this difference can be detected only by comparing the subject of mathematics and logic in objective reality.

Thirdly, if the comparison of science subjects takes place in an epistemological aspect, it is appropriate to consider these sciences from the point of view of their epistemological characteristics, for example, in the light of their epistemological premises (simplifications and idealizations accepted when they reflect reality).

Of course, it is necessary to consider only the most essential epistemological prerequisites for distinguishing subjects of sciences. These prerequisites are introduced by (1) indicating the essential that science singles out in the object in its pure form; (2) indications of what this science is distracted from (abstracted) as irrelevant to its tasks; (3) indications of what science distinguishes when displaying an object and what it does not distinguish (identifies); (4) indications of the limits to which this science accurately reflects reality, etc. Since it is important to distinguish between sciences by their properties of reflecting objective reality, which represents specific systems that have a very specific content and form, it is appropriate to conduct an analysis sciences regarding only this kind of systems. Then it is possible to establish the differences of mathematics, logic and natural sciences.

Natural science necessarily reflects the specific content of reality systems; and the content that is essential for the tasks of this science. At the same time, this science is distracted from content that is not essential for its tasks. Therefore, each natural science studies reality with precision to a very specific and essential content, highlighting this content in its pure form. In this case, natural science distinguishes the reflected reality based on a significant, specific content. Objects do not differ (i.e. are identified) by this natural science according to non-essential factors of content. For example, physics studies all kinds of material bodies, highlighting the property of bodies to have mass as essential for its tasks. She can be distracted from other properties of these bodies as if they were unimportant. In this case, all material bodies (living and inanimate) that have the same mass do not differ. Bodies are distinguished by an essential property for physics - mass. This does not exclude the fact that physics can consider other properties of material bodies and make distinctions and identifications based on these properties. It is important that physics, as well as other natural sciences, as an essential necessarily highlights some specific content of specific systems being studied, for example, the mass of bodies that make up this system. In other words, natural science is not abstracted from any specific content of systems of reality. She definitely considers any specific content as significant for her. In this, the natural sciences have an important difference from mathematical theories.

Mathematical theory, which singles out only the form of specific systems as essential and distracts from their content as non-essential, studies reality with precision to the form, that is, distinguishes different forms and does not distinguish the content of systems that have the same form. The latter makes it possible to apply mathematical theory (or give a mathematical description) to systems of any content (of any nature) that have the same form. This is evident in the fact that the same mathematical formula can be interpreted in the most diverse areas of reality. Thus, mathematics reflects reality in a more abstract form than natural science, deviating from concrete content. Formal logic reflects reality in an even more abstract form.

Logical theory, reflecting reality as essential for its tasks, singles out in its pure form only the relations of belonging to the objects of the reality of properties or relations, deviating from the specificity of their content and form as non-essential. For the sake of brevity, we will call the very fact that objects have any properties and relations a relation of belonging. Property relationships can be very different. For example, some property can be inherent in all objects or some, it can be possibly inherent, necessarily inherent or accidentally inherent, etc. There are various connections between belonging relations. For example, if some property is inherent in all objects, then it is inherent in some. If a property is inherent in some object, it is inherent in that object or some other object, and so on. Logic studies the specifics of the relations of belonging and the connections between them - and formulates its laws. Undoubtedly, reflecting the relations of belonging, logic simplifies, roughens and idealizes them; and sometimes very strongly. However, the latter complicates, but does not prevent, seeing the connection between logic and reality.

From what has been said, it follows that logic deviates from the specificity of qualitative relations studied by natural sciences, but also from the specificity of quantitative relations studied by mathematics. It is also very important to note that logic has in objective reality a subject that is different from the subject of mathematics. The latter can be seen in the qualitative difference between the truths of logic and mathematics. This statement is indirectly confirmed by K. Gödel's well-known theorems on the completeness of the calculation of predicates of the first degree and the incompleteness of formalized arithmetic. Without clarifying this problem, let's say that the truths of logic (logical laws) can be completely described axiomatically, which cannot be said about the truths (laws) of mathematics, even the arithmetic of natural numbers. Therefore, neither logic can be "reduced" to mathematics, nor mathematics to logic.

### 1.3. Specificity of mathematical abstractions

The question of the nature of mathematical abstractions is important not only in general philosophical terms for adequate criticism of modern empiricism, apriorism and conventionalism in the theory of knowledge, but also in solving specific methodological problems of mathematics itself.

To analyze these problems, it is first necessary to clarify such concepts as abstraction and abstract object in relation to mathematics.

The term "abstraction" generally means, firstly, the moment of distraction from the non-essential properties of objects in the process of forming a general concept (imagination), and secondly, the result of the process of abstraction, that is, the abstract concept itself. In the field of mathematics, any abstract concept is (at least potentially) an object of consideration, and in this sense the concepts of "mathematical abstraction" and "abstract mathematical object" are identical.

Most of the concepts with which we operate in everyday language are abstractions, since they refer to some class of objects. Thus, the concept of "person" is an abstraction, since the meaning of this concept does not include the individual characteristics of individual people. Mathematical concepts, however, are not just abstractions, they are abstractions of a special type called *idealizations*. Mathematical concepts have a property that qualitatively distinguishes them from the concepts of other substantive sciences. This property is a strict logical condition.

All concepts, even the concepts of everyday language, are defined in one way or another, because we can explain their meaning, as is usually done in explanatory dictionaries and encyclopedias. However, definitions relating to everyday language and substantive knowledge in general, except in certain cases, are only indicative in nature; they focus on a certain object, property, or relation, but neither on their own, nor together with any general principles, do they exhaust all the properties of that object. In other words, in content sciences, except in special cases, the definition is not identical to its meaning. (Special cases refer to conventions when we agree to use concepts only in a strictly specified sense, for example, to consider electromagnetic oscillations with a wavelength from 510 to 560 mmkm as green. Such conventions, however, are of secondary importance in content sciences). On the contrary, in mathematics, a mathematical object is completely defined by its definition, a system of agreements about its possible use. We operate with the concepts of point, line, vector, and others in mathematics not on the basis of substantive ideas about these objects, although such ideas are important from a heuristic point of view, but solely on the basis of how they are defined to each other in the initial positions of the given theories; the content of these and other mathematical objects is laid completely in their definitions, it can be revealed only through the analysis of these definitions, in a specific system of axioms.

The very axioms or basic principles of mathematical theory can be understood as a system of statements that implicitly determines the meaning of the basic concepts of a particular theory. The mathematical object, thus, radically differs from the object of another substantive theory in that it is given logically, that all its properties are potentially contained in its definition, and it itself makes sense only in relation to a specific system of basic definitions.

The requirement of complete logical certainty of the concept is an essential requirement of mathematical theory: fragments of knowledge where this condition is not fulfilled, where we cannot reason about the object based only on its definitions, cannot be attributed to mathematical knowledge. We will say that mathematical concepts are not just abstractions and not just idealizations, but constructions or constructs, in the sense that their possible properties are specified explicitly or implicitly with the help of a certain system of logical requirements, through relation to other idealized objects and can be studied only on the basis of these requirements.

From this follows the main feature of mathematical science, that all its statements are substantiated only in the form of evidence, and not on the basis of experience or experiment. The proof of a mathematical statement means only that the relation it asserts is implicit in the basic definitions of the theory and in the more partial definitions we are currently talking about. For the same reason, mathematical statements are not tested and rejected in experience. If, for example, the properties of a real triangle do not exactly correspond to the properties of a triangle in Euclidean geometry, this does not mean that Euclidean geometry is incorrect, but only that a geometric triangle, as a certain ideal object, does not describe all the properties of real empirical triangle. Such a situation may be a reason for constructing other geometries more adequate for this case, but it is not an argument for abandoning Euclidean geometry as a certain ideal model, valuable in many areas of experience, in technology, etc. Mathematical theories are not refuted by the facts of experience precisely due to the fact that they are internally closed, idealized models, not related to any specific field of experience, but not at all due to the special reliability of mathematical knowledge, as Descartes and Leibniz thought about it, for example.

Thus, mathematics is not just a more abstract knowledge – it differs from other substantive knowledge qualitatively, by the logical status of its concepts. Abstract objects of mathematics are, at the same time, special logical constructions defined on the basis of a system of general definitions. That is why they are objects of mathematical knowledge.

This does not mean that mathematical creativity is detached from experience, that it represents a process of free construction and arbitrary agreements. Mathematics introduces and improves its definitions not arbitrarily, but ultimately focusing on real relationships, striving to provide the most adequate apparatus for describing these relationships. Independence of mathematical statements from experience in their proof and refutation does not mean functional independence,

independence of mathematics from experience in defining and improving its concepts. These two points are often combined, as a result of which clarification of the specificity of mathematical knowledge, its certain autonomy from experience, is often qualified as an attempt to separate mathematics from experience, to ignore its practical purpose, etc.

Speaking about abstraction as a moment of formation of mathematical concepts in general, we leave aside the question of which properties of real objects we abstract from, and, conversely, which idealized properties we attribute to mathematical objects as such. However, when considering a number of methodological problems, it becomes essential, because it turns out that the specifics of mathematical theory and the difficulties of its justification depend on the nature of the idealization laid at its foundation.

The most significant role in the internal structure of mathematics is played by abstractions related to infinity. There are mathematical theories dealing only with finite sets. However, this is typical for mathematics in general. All basic mathematical theories, including theories of elementary mathematics (arithmetic, geometry, elementary algebra), are connected in one way or another with the assumption of infinity.

Mathematics is diverse both in methods and in the nature of its objects due to the diversity of its tasks, and ultimately due to the diverse scope of its application.

### 1.4. The problem of the existence of mathematical objects

The question of the status of abstractions and abstract objects in mathematics is closely related to the most general question about the meaning of existence in mathematics. What objects are permissible in mathematics in general? What does it mean to exist in relation to the idealized objects with which mathematics operates? We have already partially answered this question by defining a mathematical object as an idealization, which is at the same time a logical construction, that is, an entity given in the form of internal definitions. For a more concrete clarification of the essence of the problem, it is useful to consider the main positions on this issue that took place in the history of mathematical and philosophical thought.

Plato, as is known, attributed mathematical objects (numbers, figures) to the world of ideas, as a result of which they were attributed a greater reality of existence than the material things surrounding a person. Mathematical existence in Plato is sharply separated from corporeal, physical existence. He seeks to justify this opinion by the very practice of mathematical thinking: And indeed, when geometers use drawings and draw conclusions from them, their thoughts are not so much directed to the drawing, but to those figures whose likeness it serves. They make their conclusions for the quadrilateral itself and its diagonal, not for the diagonal they drew. The quadrilateral itself is a supersensible entity, perceived only by the inner gaze.

Aristotle rejected the Platonic world of ideas, and with it the special non-physical existence of mathematical objects. Objects of mathematics for Aristotle are just imaginary distractions from real things or, speaking in modern language, only idealizations. A mathematical object, from Aristotle's point of view, exists only in the head, as a representation, but not as any external reality in relation to thinking.

The view of mathematical objects as a distraction from the variety of properties of real objects is also typical of the science of the XVII-XVIII centuries. Newton interprets geometry as "pure kinematics", i.e. as an abstract scheme of possible mechanical motion. From this point of view, mathematical existence is not identical to physical existence, but at the same time it is directly related to it, representing its imaginary imprint.

This interpretation of mathematical existence gradually contradicted the facts. Already for Leibniz, the question was relevant: should mathematical infinity directly reflect real infinity or does it have a certain independent definition? Mathematicians gradually began to realize that mathematical images have a certain autonomy from physical reality. But if this is so, then the justification of actions with infinities and other abstract objects of mathematics cannot be obtained on the basis of experience, but must be carried out within the framework of mathematics on a logical basis.

At the beginning of the 19th century A. Cauchy introduced existence theorems into mathematics, which marked a new stage in the understanding of the status of a mathematical object. If the existence of a derivative of a continuous function for Newton was an obvious geometric and mechanical fact (mechanical movement along a trajectory always has a speed at any point), then Cauchy doubted this and demanded a purely analytical justification for the existence of a derivative at this point of each specific function. In the understanding of the mathematical existence of the XIX century. a logical point came to the fore, the requirement to substantiate the admissibility of a particular construction or assumption without reference to external empirical circumstances, but exclusively taking into account the accepted mathematical definitions.

Despite this significant progress in the separation of mathematical and physical existence, mathematics at the beginning of the XIX century. is still considered in a number of natural sciences as a special rigorous science, but a science that reflects some realities in its concepts and is based on some indisputable truths about the world. In particular, geometry is invariably interpreted as the science of real space. The discovery of non-Euclidean geometries put an end to this kind of naturalistic understanding of mathematical knowledge. Due to the understanding of non-Euclidean geometries by the end of the 19th century. it was clear that mathematics occupies a very special place among the sciences: it is not a science directly about nature or any other empirical reality, but only a strict language for meaningful (empirical) sciences, and to fulfill its function it can create forms of arbitrary nature, which satisfy only the requirements of logical consistency. From this point of view, any mathematical object defined by self-contradictory definitions is considered to exist. This new understanding of mathematical existence was clearly formulated by Cantor, Poincaré, Hilbert, Wundt, Cassirer and a number of other mathematicians and philosophers of the late 19th and early 20th centuries.

In the 20th century the problem of existence in mathematics is discussed mainly in the logical plane. The requirement of non-contradiction of definitions remains declarative until effective ways of substantiating this non-contradiction are specified. This is where the whole problem of substantiating mathematics in the 20th century arises. and in particular, the question of the admissibility of the abstraction of actual infinity in the definition of a mathematical object. Already from general epistemological considerations, it is clear that this issue cannot be resolved absolutely, in the form of a single and final system of requirements. This does not exclude, however, the progress of logical research, which leads to an increase in the reliability of mathematical knowledge, in particular, to the formulation of more and more adequate requirements that guarantee the theory from contradictions.

### 1.5. The problem of the truth of mathematical knowledge

The problem of truth makes sense primarily in meaningful theories of mathematics. Such theories include theories of meaningful pure mathematics, applied mathematics, and metamathematics. However, the content of these three types of mathematical knowledge is very different. The content of theories of pure mathematics are systems of abstract mathematical objects, such as sets of numbers (number theory), geometric figures (geometry) or any abstract objects (general or abstract set theory). The content of the theories of applied mathematics is formed by various mathematical models, which are used to interpret the theory of pure mathematics. The content of metamathematical theories is the structure of the mathematical theories of pure mathematics themselves, for example, systems of sequences of symbols and formulas, with the help of which the propositions of these theories are expressed. Such a significant difference in the content of theories of pure and applied mathematics and metamathematics determines a very important difference in solving the problem of truth in these fields of knowledge.

Methods of assessing the conformity of a judgment to the real state of affairs are called methods of assessing the truth of judgments. These methods can be divided into analytical and synthetic (empirical). Empirical methods of establishing the truth of judgments include methods of observation, measurement, and conducting experiments. It is obvious that these methods cannot be applied in pure mathematics, which deal with abstract objects and relations. Empirical truth is possible only in applied mathematics, where the abstractions of pure mathematics are interpreted using concepts that reflect the properties and relationships of real objects,

A characteristic feature of pure mathematics, which distinguishes it from natural science and other experimental sciences, is that in its proofs it never resorts to empirical methods - experiments and observations. We can measure the sum of the interior angles of a triangle a thousand times and make sure that it is 180°. But such observations will not be considered evidence. The first thing to realize about pure mathematics is the abstract, idealized nature of its objects. Already the initial objects of geometry and arithmetic, as the oldest branches of mathematical knowledge, are significantly different from the objects of natural science, because they are abstractions and idealizations of a higher level. Indeed, when, for example, in Euclidean geometry they speak of a point as an object that has no dimensions, or a straight line as a line that has neither width nor thickness, they mean precisely idealized, not real objects . Therefore, mathematical objects are characterized as abstract and idealized. This means that they are formed both due to the distraction of essential for mathematical study properties from non-essential ones, and as a result of endowment with such properties that real objects do not have.

Indeed, observing various white objects, we can abstract from their inherent property and form the concept of "whiteness". However, the property of "straightness", which characterizes a straight line in geometry, is absent in real prototypes of this concept, i.e., lines that are considered straight in the physical sense of the word. That is why the empirical and simplified approach to abstract objects as observed in experience could not provide an adequate explanation of the nature of mathematical reality. In fact, this kind of approach to the truth of mathematical judgments put "on the same board" the truth of judgments about empirically given objects (material objects) with the truth of judgments about idealized objects that have no empirical existence. In fact, such an approach to mathematical truth is an extrapolation of the truth of applied mathematics to the truth of pure mathematics, which, in fact, does not solve the problem of the truth of the latter.

Proponents of empiricism do not see the complex, contradictory nature of the development of scientific knowledge, they underestimate the importance of the role of creative thinking in this process, the necessity and fruitfulness of increasingly complex abstractions and idealization in the development of science.

This can be seen most vividly, perhaps, from the example of the discovery of new, non-Euclidean geometries by M. I. Lobachevskyi, Y. Boyai, Do. F. Gauss and B. Riemann. It was created in the III century. to n. e. Euclid's geometry was considered the only possible true teaching about the properties of the physical space surrounding us for more than two millennia. After Lobachevskyi, Boyai and Gauss built hyperbolic, and Riemann elliptic non-Euclidean geometry, the situation changed radically. True, at the beginning, many scientists looked at these geometries as purely mathematical exercises, and not as possible theories of real space. Later, when the (relative) logical non-contradiction of non-Euclidean geometries was proven, serious disagreements arose among scientists, which even resulted in a crisis of the foundations of geometry. Indeed, if non-Euclidean geometries are as logically consistent as Euclidean geometry, which one is true? And can geometric systems that contain postulates that contradict each other, such as postulates about parallel lines in Euclidean and non-Euclidean geometries, be considered true?

The way out of these difficulties and the crisis in the foundations of geometry was found by rejecting the traditional ideas that considered geometry as a teaching about the description of the empirical properties of space. A radically new view of geometric systems, prepared by the discovery of non-Euclidean geometries, was to see in these systems abstract statements, the empirical truth of which can be verified after the corresponding concrete interpretation of the basic concepts and axioms of these systems on certain systems of real objects. In other words, now theorems and axioms are no longer associated with the single interpretation that Euclid indicated in his geometry (that is, with points, lines and planes as idealized images of our spatial ideas). Moreover, they are not related to any single interpretation not only of systems of empirical objects, but also of ideal mathematical objects. Such a new view of geometry was expressed in D. Hilbert's well-known book "Fundamentals of

Geometry", published in 1899. It shows that geometric objects can mean any system of things satisfying the corresponding axioms. So, for example, a "point" can be understood as an ordered triple of real numbers, a "line" - a linear equation with three unknowns, as is done in analytical geometry. Geometric terms can be given a non-mathematical interpretation, considering, say, a point on a plane as a state of a physico-chemical system, etc. Hilbert jokingly even said that if you replace the words "point", "line" and "plane" with the words "table", "chair" and "beer mug", then nothing will change in the geometry.

### 1.6. The specificity of practice as a criterion of truth in mathematics

The peculiarity of the criterion of practice in mathematics essentially depends on the specific nature of the relation of mathematical theories to reality. If the theory during its interpretation becomes a field of empirical knowledge (physical, biological, economic, etc.), then in it the criterion of practice is the same direct criterion as in other empirical sciences in general.

In pure mathematics, which studies systems of abstract mathematical objects, practice as a criterion of truth cannot act directly, since material activity with abstract objects is impossible, and operation with material images of these objects cannot solve the question of the truth of the corresponding mathematical constructions. For example, no practical method can solve the question of the proportionality of the diagonal and the side of a square. Therefore, the criterion of practice can be applied as a criterion of truth in mathematics only indirectly, for example, through justification. Yes, any theory of pure mathematics must be logically consistent, whatever the system of mathematical objects. However, non-contradiction is not the same as the truth of the theory, it only indicates the possibility of applying the theory to the study of reality, that is, its truth or, more precisely, the correctness of the interpretation. If we judge the truth of pure mathematics taking into account analytical methods, then in fact the criterion of non-contradiction itself is chosen from the needs of the empirical application of mathematics, that is, the adequate reflection of reality in mathematical theories. That is why practice indirectly determines the truth of a mathematical theory - through establishing its consistency, correct interpretation.

Of course, there was a time when pre-theoretical mathematics was directly woven into the material activities of people. Then it was checked and developed directly taking into account practice. But already in the III century. to n. e. the ancient Greeks turned it into a theoretical science, which substantiates its propositions not with the help of empirical experience, but with the help of deductive proof. In the future, the connection of mathematics with social and material production and practice as a whole becomes more and more complex and mediated.

Proposing practice as the determining basis of development and criterion of truth in mathematics, rational philosophy does not deny the relative independence of the internal sources of its progress and the presence of auxiliary criteria of truth in it. Such a criterion is, as we have seen, the logical consistency of theories. However, it is important to understand that these are auxiliary criteria that ultimately also rely on the practice criterion. From a philosophical point of view, the relative nature of practice itself as a criterion of truth is that this criterion can never in its essence confirm or refute completely any human conception.

## 1.7. Questions and tests for self-testing of knowledge

1. How are mathematical abstractions and objects of the real world related?
2. Where are the objects of mathematical knowledge?
3. By what criteria is the truth of mathematics conclusions determined?
4. The specificity of the interaction of mathematics and logic.
5. What is the "special place" of mathematics in the natural sciences?
6. Are mathematical abstractions a reflection of objective reality?
7. Define the content of "ideal objects" of mathematical research.
8. What is the specificity of mathematical abstractions?
9. What is the specificity of the existence of research objects in mathematics?

# Topic II. Principles of modern physics: philosophical analysis

## 2.1. Symmetry principles and conservation laws

Various forms of matter movement are described in modern physics, as mentioned earlier, by fundamental theories. Each of these theories describes quite certain phenomena: mechanical or thermal motion, optical, electromagnetic processes, etc.

There are general laws in the structure of fundamental physical theories that cover all processes, all forms of matter movement. These are primarily the laws of symmetry or in-variance, and the related laws of conservation of physical quantities.

Symmetry in physics- it is a property of physical laws that describe the behavior of systems in detail, to remain unchanged (invariant) under certain transformations to which the quantities included in them can be subjected.

Laws of conservation of physical quantities this is the statement according to which the numerical values of some physical quantities do not change over time in any processes or in certain classes of processes. There is a connection between symmetry principles and conservation laws established by E. Nether's theorem. In fact, in many cases the conservation laws simply follow from symmetry principles.

The huge importance of symmetry principles and conservation laws in modern physics is that these principles can be relied upon when building new fundamental theories. An indisputable condition for the justice of all laws of nature is their conformity to these principles.

The philosophical significance of the principles of symmetry and conservation laws is that they represent the most general form of determinism. These principles demonstrate the unity of the material world, the existence of a deep connection between various forms of movement of matter, and even the connection between the properties of space-time and the conservation of physical quantities.

The principles of symmetry are divided into space-time (they are also called geometric or external) and internal, which describe the specific properties of elementary particles. Let us first dwell on space- and temporal symmetries and related to them the conservation laws.

A. Time shift, i.e. changing the start of the time countdown, does not change physical laws. This means that these moments of time are objectively equal and you can take any moment to start the countdown. Time is homogeneous.

The law of conservation of energy follows from the invariance of physical laws regarding this transformation. The proof of the connection between the conservation of energy and the uniformity of time is rather complicated, and we will not dwell on it. Let's limit ourselves to one example. If the force of attraction of bodies to the earth changed over time (that is, not all moments of time were equal), then energy would not be conserved. We could lift bodies up at moments of time when the force of gravity is minimal, and lower them down at the moment when the force of gravity increases. The labor gain would be available and a perpetual motion machine could be created.

B. Displacement of the reference system of spatial coordinates does not change physical laws. Objectively, this means the equality of all points of space (homogeneity of space). The transfer (displacement) in the space of any physical system does not affect the processes in it in any way.

The law of conservation of momentum follows from this symmetry.

C. The rotation of the reference system of spatial coordinates leaves the physical laws unchanged. This means isotropic space: the properties of space are the same in all directions. The law of conservation of angular momentum follows from the invariance of the laws of physics with respect to this transformation.

D. The laws of nature are the same in all inertial frames of reference. This is the principle of relativity - the main postulate of Einstein's special theory of relativity. Accordingly, physical laws do not change during Lorentz transformations, which connect the values of coordinates and hours in different inertial frames of reference.

It follows from the principle of relativity that the speed of movement of the center of mass of an isolated system is preserved.

E. Fundamental physical laws do not change when the sign of time is reversed, that is, when the equation of the theory t is replaced by -t. This means that all relevant processes in nature are reversible in time. The irreversibility observed in the macro world has a statistical origin and is related to the non-equilibrium state of the universe.

F. There is a mirror symmetry of nature: reflection of space in a mirror does not change physical laws. In quantum mechanics, this symmetry corresponds to the preservation of a special quantum number - parity, which should be attributed to each particle.

H. The replacement of all particles with antiparticles (charge pairing operation) does not change the character of nature's processes.

The last three symmetries are more complicated than the previous ones. Mirror symmetry and charge coupling are preserved only in strong and electromagnetic interactions. Under weak interactions, these symmetries are broken.

Thus, a certain hierarchy of symmetry principles has been revealed in modern physics. Some of them are performed under any interactions, others only under strong and electromagnetic interactions. This hierarchy is even more clearly manifested in the internal symmetries, to which we will now turn.

A. For all transformations of elementary particles, the sum of electric charges of particles remains unchanged. This is the law of conservation of electric charge. The law of conservation of electric charge is organically included in the structure of modern physical theories, but the deep reasons for the implementation of this law remain unknown.

In quantum mechanics, the conservation of electric charge corresponds to some transformation of the wave function (calibration transformation), which does not change the equations of this theory,

B. Experience shows that nuclear matter is preserved: the difference between the number of heavily interacting heavy particles (baryons) and the number of their antiparticles does not change during any processes, Baryons can be born only in pairs: particle - antiparticle. The lightest baryons – protons – do not decay into other particles. This can be interpreted as follows: each baryon must be assigned a special quantum number - a baryon charge equal to +1, and each antibaryon a -1 charge. Then the baryon charge determined in this way is conserved.

C. It is the same with light elementary particles — leptons: electrons, neutrinos. The difference in the number of leptons and antileptons does not change during transformations of elementary particles. This is the law of conservation of lepton charge.

In unified theories of various interactions, it is assumed that electric charge must be conserved. Baryon and lepton charges may not be conserved, although experimentally, violation of the conservation of these charges has not yet been detected.

D. One of the long-known internal symmetries is isotopic invariance. The charge independence of strong interactions, that is, their independence from electric charge, was experimentally established. For example, the strong interactions of a proton with a proton and a neutron with a neutron are exactly the same due to their independence from electric charge. Therefore, V. Heisenberg proposed to consider the proton and neutron as two different states of one particle - the nucleon. Proton and neutron differ only in that the proton is electrically charged, and the neutron is not. The slight difference in their masses is caused by electromagnetic interactions. With strong interactions, they act as one particle. Charge independence is characteristic not only for nucleons, but also for all strongly interacting particles.

As it could be seen from the above, the theory of interactions of elementary particles is developing successfully. The beginning of this development was laid by the principles of symmetry. Even now, the principles of symmetry are leading in this field of physics.

In conclusion, let us emphasize that the laws of symmetry have an unambiguous (in this sense, dynamic) character, which does not allow any statistical scatter for the values of physical quantities that are preserved. Thus, they should be considered as dynamic elements of the overall statistical picture of the world. Due to their unambiguous nature, the laws of conservation and symmetry, no matter how successfully their development and generalization progress in the future, will not be able to replace the theory that explains statistical processes in the microcosm in detail, and this requires their addition by other laws.

## 2.2. The principle of conformity

All fundamental physical theories and more specific laws are a reflection of reality. All of them to one degree or another are approximations to objective regularities. As science develops, deepening our knowledge, less accurate theories are replaced by more accurate ones that describe the same forms of matter movement as previous theories and that cover a wider range of processes. This was already mentioned when considering the change of dynamic theories by deeper statistical theories.

Every fundamental physical theory has certain limits of application. And these boundaries are set very strictly and precisely if a deeper theory describing the same processes is discovered. For example, classical Newtonian mechanics correctly describes the movement of large (macroscopic) bodies only in those cases when their speed is much lower than the speed of light. This became clear after the creation of the special theory of relativity and the construction of relativistic mechanics, valid for describing the movement of bodies with any speeds as close as possible to the speed of light.

It is very important that the creation of a new theory, such as relativistic mechanics, does not at all mean that the old, non-relativistic classical mechanics loses its value. The motion of macroscopic bodies with velocities much less than the speed of light will always be described by Newtonian mechanics. In this field of velocities, relativistic mechanics gives meager corrections, accounting for which is simply meaningless.

Here we come close to the correspondence principle, which asserts the continuity of physical theories. This principle was first formulated in an explicit form by N. Bohr in 1923, at the dawn of the creation of the quantum theory of the movement of microparticles. Bohr's idea was that since the laws of classical mechanics are confirmed with great accuracy in a wide range of phenomena, it should be assumed that a new, more accurate theory of these phenomena should give the same results as Newton's mechanics. This statement imposes strong limitations on the new theory. No new theory can be valid unless it contains as a limiting case the old theory relating to the same phenomena, because the old theory has already justified itself in its field.

The inapplicability of classical mechanics to describe processes with microparticles became abundantly clear after E. Rutherford proposed the planetary model of the atom. Atoms, in which the movement of electrons would obey the laws of classical physics, could not exist. Electrons with accelerated movement around the nucleus should lose energy by emitting electromagnetic waves and fall on the nucleus. With the creation of quantum mechanics, another limit to the application of classical mechanics was established. In the quantum theory, another universal world constant is introduced, similar to the speed of light in the special theory of relativity. This is the famous Planck constant h or quantum of action.

It turned out that the mechanical quantity, i.e. the action, which has the dimension of the product of the momentum of the particle by the traveled path, has a decisive role in the transition from quantum mechanics to classical. Here we are dealing with a partial manifestation of the principle of correspondence. In its general form, this principle is formulated as follows: theories, the validity of which was experimentally established for a certain group of phenomena, are not rejected with the construction of a new theory, but retain their significance for the former field of phenomena, as the ultimate expression of the laws of new theories. The conclusions of the new theories in the area where the old theory is correct pass into the conclusions of these old theories. The mathematical apparatus of the new theory contains a certain characteristic parameter that plays the role of the scale of natural phenomena (for example, the speed of light and Planck's constant). This parameter does not turn into a mathematical apparatus of the old theory, if the value of the parameter plays the role of a domain in which the old theory is valid.

The principle of correspondence is a concrete expression in the physics of dialectics of the ratio of absolute and relative truths. Every physical theory – a degree of knowledge – is a relative truth. Changing physical theories is a process of approaching the absolute truth, a process that will never be completely completed due to the infinite complexity, infinite variety of the world around us.

At the same time, the principle of correspondence expresses the objective value of physical theories. New theories do not deny the old precisely because the old theories with a certain degree of approximation reflect the objective regularities of nature.

### 2.3. The principle of additionality and the ratio of uncertainties

Another physical principle - the principle of additionality - arose from attempts to understand the reason for the appearance of contradictory visual images that have to be associated with objects of the microcosm.

In a number of experiments, the electron and other elementary particles exhibit corpuscular properties, that is, properties of particles. Any device for detecting micro-objects always registers them as a whole, localized in a very small volume of space. Neutrons and protons have dimensions of the order of 10~13 cm, and electrons behave as point particles. No modern experiment is capable of capturing the dimensions of an electron. In Wilson's chamber, you can see only traces of particles that have flown by - tracks.

On the other hand, during motion, all microparticles exhibit typical wave properties. Interference and diffraction of particles on crystal lattices or artificially is observed. created obstacles. The electron and other particles behave like waves that bend around obstacles and, as it were, simultaneously pass through several slits of the diffraction grating.

Thus, all micro-objects are said to be characterized by particle-wave dualism. The general answer to the question of how these contradictory properties are combined in one object was given by N. Bohr.

First of all, Bohr emphasizes, it is necessary to clearly realize that we perceive the microworld through the prism of the macroworld. The fact is that all devices that record individual acts in the microcosm are macroscopic and cannot be otherwise.

Our sense organs do not perceive micro processes. An important conclusion follows from this: the concepts we use to describe phenomena are macroscopic concepts, in terms of which the operation of the device is described. But these concepts cannot be fully applied to micro-objects, since their behavior does not obey the laws of classical mechanics.

According to Bohr's principle of complementarity, two mutually exclusive (complementary) sets of classical concepts (for example, particles and waves) must be used for a complete description of quantum mechanical phenomena. Only a set of such concepts provides comprehensive information about these phenomena as a whole.

We can safely say that the principle of additionality is the result of a philosophical understanding of a new unusual physical theory - quantum mechanics. It expresses on a microscopic level one of the main laws of dialectics, discovered by H. Hegel and K. Marx - the law of unity and struggle of opposites.

A partial expression of the additionality principle is Heisenberg's uncertainty ratio.

Speaking of a particle, we imagine a lump of matter that is currently in a certain place, has a certain energy and moves at a strictly defined speed. At the same time, we assume that it is possible to precisely specify the coordinates, momentum, and energy of a particle at any moment.

However, by associating a particle with a wave, we move to the image of an unlimited sine wave extending throughout space. The expression "wavelength at this point" cannot make sense. Therefore, the concept of momentum at a point cannot make sense. Likewise, the concept of the energy of a particle at a given moment of time does not make sense. The fact is that energy, according to Planck's formula, is related to the frequency of the wave, and the concept of frequency refers to a harmonic oscillatory process that occurs in time. The statement that the electron can only be approximately considered as a material point means that its coordinates, momentum and energy can only be approximately given. Quantitatively, this is expressed by the Heisenberg uncertainty ratio.

However, the physical interpretation of quantum mechanics cannot be considered complete. Discussions are still ongoing on many issues. In particular, according to the physical and philosophical content of the principle of additionality and the ratio of uncertainties. A full understanding of these issues-this is a matter for the future.

### 2.4. Questions and tests for self-testing of knowledge

1. The essence and significance of symmetry in physics.

2. How are the principles of symmetry and the laws of conservation of physical quantities related?

3. Types of symmetry principles.

4. The specificity of space-time symmetry of the physical world.

5. Correlation between the principles of symmetry and statistical laws.

6. What is the essence of the principle of conformity?

7. Is physical theory relative or absolute truth?

8. The principle of correspondence and classical mechanics - ratio.

9. What is the principle of additionality and uncertainty ratio?

10. Who is the author of the principle of additionality?

11. What is the essence of Heisenberg's uncertainty ratio?

12. Who owns the discovery of the principles of conformity and complementary?

a) A. Einstein;

b) M. Plank;

c) N. Boru;

d) V. Heisenberg;

e) I. Newton.

# Topic III. Philosophical and methodological problems of determinism in modern physics

## 3.1. The principle of determinism and the laws of physics - a relationship

Problems related to the categories of determinism and causality in modern physics are the most relevant philosophical problems of natural science. The main content of these problems is the analysis of the relationship between dynamic and statistical laws (theories) and objective regularities. In the interpretation of this ratio, the philosophical directions of determinism and indeterminism occupied directly opposite positions throughout the history of science.

Determinism is a philosophical doctrine about the objective, regular relationship and interdependence of the phenomena of the material and spiritual world. The central core of determinism is the proposition about the existence of causality. The idea of determinism, thus, is that all phenomena, events in the world are arbitrary, but obey objective laws that exist outside and independently of their knowledge.

In modern physics, the manifestation of determinism is associated with the existence of objective physical laws and finds the most complete and general reflection in fundamental physical theories.

Fundamental physical theories (laws) are the quintessence of our knowledge of physical regularities; approximate, but to date, the most complete reflection of objective processes in nature. All the variety of partial (derived from fundamental) physical laws such as Archimedes' law, Ohm's law, the law of electromagnetic induction, radioactive decay, etc. are the consequences of certain fundamental theories.

To solve the problems of determinism, it is important to divide physical laws (and thus theories) into dynamic and statistical (probabilistic) ones.

The dynamic law is a physical law that reflects an objective regularity in the form of a unique relationship of physical quantities expressed quantitatively. The unambiguity of the connection of physical quantities in a physical law is perceived as a functional connection, in which the arguments of the function and its value are completely certain physical quantities. A dynamic theory is a physical theory that is a set of dynamic laws. Statistical laws and theories will be discussed later. First, let's consider the form of determinism associated with dynamic laws.

### 3.2. Mechanical and probabilistic determinism in physics

Mechanical (classical) determinism is connected with fundamental physical theories of a dynamic nature. Historically, the first and simplest theory of this type is I. Newton's mechanics. It is also worth paying attention to another fundamental physical theory of a dynamic nature - Maxwell's electrodynamics (their essence is sufficiently revealed in philosophical and scientific literature).

Other fundamental theories of a dynamic nature have the same structure as Newton's mechanics and Maxwell's electrodynamics. These include: mechanics of continuous media, thermodynamics and the theory of gravity (now - the general theory of relativity).

The unambiguous relationships of precisely fixed physical quantities introduced in Newtonian mechanics, in fact, only create the illusion of absolute classical determinism, because here the idealized possibility of absolutely accurate predictions of motion based on the absolutely accurate fixation of initial conditions is assumed.

There is no doubt that Laplacian determinism with a certain degree of idealization reflects the real movement of bodies and in this respect it cannot be considered false. But its absolutization as an accurate reflection of reality is inadmissible.

With the assertion of the main importance of statistical regularities in physics, the "superhuman" ideal, presented to science by the concept of absolute determinism, disappeared, and the very idea of "omniscient consciousness", for which the destinies of the world are absolutely precisely and unambiguously determined in advance, disappears. We will now move on to getting acquainted with statistical regularities.

The idea of laws of a special type, in which the relationships between the quantities included in the theory are ambiguous, was first introduced by Maxwell in 1859. Maxwell was the first to understand that when considering systems consisting of a huge number of particles, it is necessary to set a completely different task , than was done in Newtonian mechanics. For this, Maxwell introduced into physics the concept of probability, developed earlier by mathematicians in the analysis of random phenomena, in particular gambling (such as, for example, a game of dice).

This probability itself has an objective character, as it expresses the objective relations of reality and its introduction is not due only to our ignorance of the details of the course of objective processes.

Against the background of many random events, a certain regularity is revealed, which is expressed by a number. This number - the probability of an event - allows you to determine statistical averages.

Undoubtedly, the motion of the thrown dice is quite simple to analyze and draw conclusions from. Maxwell was interested in a fairly complex process - the behavior of gas molecules in a closed vessel. The problem of determining the exact momentum of a molecule at the moment seemed insurmountable. But Maxwell managed to solve this task! The statistical law of distribution of molecules by pulses turned out to be simple. But Maxwell's main merit was not in the solution, but in the formulation of a new problem. He clearly realized that the random behavior of individual molecules in given macroscopic conditions is subject to a certain probabilistic (or statistical) law. In a speech to the Cambridge Philosophical Society, he said: "I believe that molecular theories are of the greatest importance for the development of our methods of thought because they force a distinction to be made between two kinds of cognition, which we may call dynamical and statistical."

After Maxwell's impetus, the molecular-kinetic theory (or statistical mechanics, as it was later called) began to develop rapidly. L. Boltzmann built the kinetic theory of gases. Statistical mechanics reached its conclusion in the works of

V. Gibbs, who created an efficient and sophisticated calculation method for any systems (not only gases) in a state of thermodynamic equilibrium. Finally, the foundations of the statistical theory of non-equilibrium processes were laid.

What are the general indicators of statistical laws (and theories)?

First, in statistical theories, any state is a probabilistic characteristic of the system. This means that the state in statistical theories is determined not by the values of physical quantities, but by *statistical (probability) distributions* of these quantities. This is a fundamentally different characteristic of the state than in dynamic theories, where the state is defined by the values of the physical quantities themselves.

Secondly, due to the first feature in statistical theories, based on a known initial state, not the values of physical quantities themselves, but the probabilities of these values within given intervals are uniquely determined as a result. Thus, the average values of physical quantities are unambiguously determined. These average values in statistical theories play the same role as physical quantities themselves in dynamical theories. Finding the average values of physical quantities is the main task of statistical theories. The probabilistic characteristics of the state in statistical theories are quite different from the characteristics of the state in dynamic theories. But, nevertheless, dynamical and statistical theories reveal a remarkable unity in essence. The evolution of the state in statistical theories is uniquely determined by the equations of motion, as in dynamic theories. According to a given statistical distribution (with a given probability) at the initial moment of time, the equation of motion uniquely determines the statistical distribution (probability) at any subsequent moment of time, if the energy of interaction of particles with each other and with external bodies is known. The average values of all physical quantities are uniquely determined accordingly. Here there is no difference from dynamic theories regarding the unambiguity of the results.

Due to the unambiguous connection of states, statistical theories express necessary connections in nature (necessary connections in nature cannot be expressed otherwise than through an unambiguous connection of states).

The most important philosophical problem of physical determinism is the problem of the existence of objective statistical regularities, that is, the interrelationships of objectively probabilistic physical phenomena. Determinism in statistical patterns is a deeper form of determinism in nature. It reflects a specific form of determinism. In contrast to hard classical determinism, it can be called probabilistic determinism (or modern determinism).

Statistical laws and theories are a more perfect form of description of physical regularities, because any known process in nature is more accurately described by statistical laws than by dynamic ones. The unambiguous connection of states in statistical theories testifies to their commonality with dynamic theories. The difference between them is in one way - in the method of fixing (description) the state of the system.

The real, comprehensive meaning of modern (probabilistic) determinism became obvious after the creation of quantum mechanics - a statistical theory that describes phenomena on an atomic scale: the movement of elementary particles and systems consisting of them. Despite the fact that quantum mechanics is significantly different from classical theories, the structure common to fundamental theories is preserved here as well. Physical quantities (coordinates, impulses, energy, angular momentum, etc.) remain generally the same as in classical mechanics. The main quantity characterizing the state is the complex wave function. It has the meaning not of the probability itself, but of the amplitude of the probability. Its square determines the probability of detecting particles in a certain region of space.

The wave function fully characterizes the state of the system. Knowing it, you can calculate the probability of detecting a certain value of both the coordinate and any other physical quantity, as well as the average values of all quantities. The basic equation of non-relativistic quantum mechanics – the Schrödinger equation – uniquely determines the evolution of the state in time. The value of the wave function at the initial moment of time determines its value at any subsequent moment of time.

Quantum statistics was built on the basis of quantum mechanics. Quantum field theory serves as a generalization of quantum mechanics in the case of a variable number of high-energy particles. These statistical theories (microscopic electrodynamics, etc.), as well as classical statistical theories, fit into the framework of the general structure of fundamental physical theories.

### 3.3. Dynamic and statistical laws and their role in understanding the essence of determinism

Immediately after the appearance of the concept of statistical law in physics, the problem of the existence of statistical laws and their relationship with dynamic laws and laws arose. Since then, it has not stopped attracting the attention of both physicists and philosophers, and is currently one of the most pressing philosophical problems of natural science.

With the development of science, the approach to the problem and even its formulation changed over time. Initially, the main problem in the relationship between dynamic and statistical laws was the question of substantiation of classical statistical mechanics based on Newton's dynamic laws. They tried to find out how statistical mechanics, the essential feature of which is the probabilistic character of predictions of the values of physical quantities, should belong to Newton's laws with their unambiguous connections between the values of all quantities.

Since statistical laws as a new type of description of regularities were initially formulated on the basis of dynamic equations of classical mechanics, for a long time dynamic laws were considered the main, primary type of representation of physical regularities, and statistical laws were considered to a large extent as a consequence of the limitations of our abilities to know them. In particular, the impossibility of tracking the change of all parameters of complex systems forces us to some indirect, statistical description.

Currently, however, the greatest interest has taken a completely different formulation of the question, opposite in some respects to the initial one. This happened after it became clear that the patterns of behavior of microcosm objects and the laws of quantum mechanics are statistical. It was then that the question was posed as follows: is the statistical description (with the help of statistical laws) of microprocesses the only possible one, or are there dynamical laws that more deeply determine the movement of elementary particles, but are hidden under the guise of statistical laws of quantum mechanics?

The emergence and development of quantum theory gradually led to a revision of views on the role of dynamic and statistical laws in reflecting the laws of nature. The statistical nature of the behavior of individual elementary particles was revealed. At the same time, no dynamical laws were discovered by the laws of quantum mechanics that describe this behavior. Therefore, outstanding scientists such as N. Bohr, V. Heisenberg, M. Born, P. Langevin and others put forward the thesis about the primacy of statistical laws. Acceptance of this thesis by the majority of materialist scientists from the very beginning was complicated by the fact that Bohr, Heisenberg and some others associated the position of the primacy of statistical laws with indeterminism, that is, a philosophical concept that denies the regular connection and conditioning of phenomena in nature and society. The fundamentally statistical nature of the laws of the microcosm meant, in their opinion, that the usual ideal of determinism was unattainable for him. The directly formulated conclusion about the absence of determination (causality) caused sharp objections from the great scientists of the older generation (A. Einstein, M. Planck, E. Schrödinger, etc.), who did not always adhere to a clear philosophical position. They insisted on the need to find dynamic laws to describe the microcosm, perceiving the statistical laws of quantum mechanics as an intermediate stage that allows describing the behavior of a collection of micro-objects, but does not yet provide an opportunity to accurately describe the behavior of individual micro-objects.

However, the statistical nature of the behavior of micro-objects clearly follows from the set of known facts. It is the statistical representations that exactly correspond to the empirically confirmed situation in atomic and nuclear physics, where all experiments are essentially based on the calculation of probabilities with which certain values of physical quantities are realized. When it became obvious that the role of statistical laws in the description of physical phenomena cannot be denied, the theory of "equality" of statistical and dynamic laws was put forward. Those and other laws were considered as "equal" laws, but which relate to different phenomena, each has its own scope of application, are not reduced to each other, but can complement each other.

This opinion, however, does not take into account the indisputable fact that all fundamental statistical theories of modern physics (quantum mechanics, quantum electrodynamics, statistical thermodynamics, etc.) approximately contain corresponding dynamic theories. Therefore, it is natural that many great scientists were inclined to consider statistical laws as the deepest, most general form of description of all physical regularities.

The works of scientists showed that there is no reason to conclude about indeterminism in nature because the laws of the microcosm are fundamentally statistical. Since determinism insists on the existence of objective regularities, then indeterminism must mean the absence of such regularities. This is certainly not the case. Statistical regularities are no less objective than dynamic ones, and also reflect the interrelationships of the phenomena of the material world. The dominant meaning of statistical laws means a transition to a higher degree of determinism, not a rejection of it altogether.

After the creation of quantum mechanics, it is possible, in our opinion, to assert with full reason that dynamic laws are the first, lower stage in the knowledge of the surrounding world and that statistical laws more fully reflect the objective relationships in nature, are a higher stage of knowledge.

This statement follows directly from the consideration of the development of physics, starting with Newtonian mechanics and up to the emergence of quantum field theory. During all this time, we see how the dynamic theories that originally arose, covering a certain range of phenomena, a certain form of movement of matter, are replaced by statistical theories that describe the same range of issues from a new, deeper point of view as science develops.

The replacement of dynamic theories by statistical ones, of course, does not mean that the "old" dynamic theories outlive their age and are consigned to the archive. Their practical value within certain limits is not diminished in the least by the fact of awareness of new statistical theories. Speaking about the change of theories, we mean, first of all, the change of less profound physical ideas with deeper ideas about the essence of phenomena, the description of which is given by the corresponding theories. Simultaneously with the change of physical representations, the field of application of the theory is expanding. Statistical theories cover a wider range of phenomena inaccessible to dynamic theories. Statistical theories are in better quantitative agreement with experiment than dynamic ones. However, according to the correspondence principle, the statistical theory leads under certain partial conditions to the same results as the corresponding simpler dynamical theory.

The fact that in modern physics, statistical theories are a higher stage of knowledge compared to dynamic ones, cannot yet serve as permanent proof that this relationship between laws reflects a general, and not a temporary situation, characteristic only of the current state of our knowledge. Philosophical justification is necessary here. It is based on the idea that the connection between the necessary and the accidental cannot be revealed within the framework of dynamic laws, because they ignore the accidental. The dynamic law reflects the necessary average result to which the course of processes leads, but does not reflect the complex nature of establishing this result. When considering a sufficient range of issues (when deviations from the required average are insignificant), such a description of the processes is quite satisfactory. However, even in this case, it can be considered satisfactory, provided that we are not interested in those complex relationships that lead to the necessary connections, and we limit ourselves only to ascertaining these connections. It is necessary to clearly imagine that there are simply no absolutely precise, unambiguous relationships of physical quantities, which dynamic laws speak of, in nature. In real processes, there are always inevitable deviations from the required average values - random fluctuations, which only under certain conditions do not play a significant role and may not be taken into account.

Dynamic laws are not able to describe phenomena when fluctuations are significant, and, what is also important, they are not able to predict under which conditions we can no longer consider the necessary in isolation from the accidental.

In dynamic laws, necessity appears in a form that roughens its connection with chance. But it is the last circumstance that statistical laws take into account. It follows that statistical laws more deeply reflect real physical processes than dynamic ones. It is not by chance that statistical laws are recognized by dynamic laws.

Let's explain what has been said using the example of the second law of thermodynamics, which summarizes empirical facts about the irreversibility of processes in nature. The second law has a dynamic form and clearly reflects the behavior of a large number of particles. But it does not reveal the essence of the micro-processes that lead to an increase in entropy, but only gives the necessary average result. This law does not show how, as a result of the complex process of the interaction of molecules, the necessary, which is manifested here in the striving of the system for the most probable state, makes its way through a multitude of accidents, which manifest themselves in the random behavior of molecules in relation to the behavior of the entire mass of matter as a whole. And, most importantly, he cannot predict under what conditions the second principle of thermodynamics ceases to be fulfilled. Only statistical mechanics copes with these tasks.

In statistical laws, in contrast to dynamic laws, necessity appears dialectically, in an inextricable connection with chance. In a certain sense, it is based on chance, and chance itself appears as a form of manifestation of necessity.

The final conclusion from the analysis of the relationship between dynamic and statistical laws (and, therefore, theories) is as follows: modern (probabilistic) determinism is a generalization of classical determinism, a new, higher stage of its development.

### 3.4. Physical laws and its causality

Initially, the concept of causation arose in connection with the practical activities of people, and it is characterized by three features: 1) temporal antecedence of the cause of the effect; 2) the same cause always determines the same effect; 3) the cause is an active agent that carries out the effect. The combination of all three features characterizes causality, which should be called a qualitative description of causality in order to emphasize its difference from a quantitative expression of causality, when the next state can be determined on the basis of the previous one strictly mathematically.

The definition of causality as a connection of states is given as the main one. However, the presence of a connection of states, which is revealed in fundamental physical theories, does not mean that only the initial conditions (coordinates and impulses in mechanics) are the cause of subsequent states. The further state is also determined by the forces acting between the bodies of the system or the interaction energy. The causal relationship of states implies the presence of force interactions between bodies, that is, it has a force character. Moreover, there is no fundamental difference between the states of an isolated and non-isolated system. If the system is not isolated, then, in addition to internal forces that depend on the distances between bodies, there are also external forces (external force field). It is clear that in the above-described case causality is a special case of physical determination.

Finally, it should be remembered that causality as a philosophical category does not necessarily refer only to the world of physical phenomena. It refers both to organic nature and to society, where relationships are by no means reduced to physical interactions, that is, to the forceful effects of one body on another. In general, in order to understand individual phenomena, we must tear them out of the general connection and consider them in isolation, and in this case, changing movements appear before us - one as a cause, the other as an effect.

Causality is directly related to the physical law, which covers many features of the objective relationship. It can be considered as a moment of general relationship. In the analysis, causation means precisely the connection of states described by fundamental physical theories, and causation is considered in relation to dynamic and statistical laws. In the first case, they speak of dynamic causality, in the second, of probabilistic causality. In particular, the system of equations for the electromagnetic field discovered by Maxwell is a cause in the sense of dynamic causality, because, like Newton's mechanics, Maxwell's theory allows for precisely fixed values of the characteristics of the electromagnetic field at the initial moment of time to uniquely find them at subsequent moments of time. New quantities determine the state of the system (fields instead of coordinates and momentum), but otherwise everything remains the same as in classical mechanics. Causality in dynamic laws became the fundamental idea of classical determinism. Probabilistic causality takes place in statistical mechanics, where the probability of certain values of coordinates and impulses at any subsequent moment can be found based on the distribution function at a given moment in time. The coordinates and momentum of the system particles are considered as random variables that are not uniquely determined by the conditions in which the system is located. Here, the probabilities of coordinates and pulses are already causally related. This is a new form of causality that can be called probabilistic causality. Probabilistic causality in statistical laws is the basis of the modern understanding of determinism.

However, both in dynamic and in statistical laws, causality has the general property of unambiguity, because in theories of both types, the state of the system at the present moment is uniquely determined by the state of the system at the previous moment. Only in the case of statistical theories, the way of describing the state becomes new, probabilistic. Probabilistic causality becomes unambiguous when the probabilities of physical quantities go to the physical quantities themselves in extreme cases, that is, when the distribution function becomes sharply singular and, therefore, the probabilities become different from zero only for strictly defined values of coordinates and momentum. We encounter probabilistic causality not only in statistical mechanics, but also in any statistical theory, in particular in microscopic electrodynamics.

Still, before the advent of quantum mechanics, it was possible to think that dynamic laws with their dynamic causality are the basis of the universe, and classical determinism has the right to exist at least as an abstract possibility.

The situation changed after the discovery of the statistical nature of the laws of motion of individual microparticles and the creation of quantum mechanics. It turns out that probabilistic causality can exist on its own, without dynamic causality behind it. Statistical laws with their inherent form of causality more deeply reflect the objective connections of nature than dynamic ones. Accordingly, probabilistic causality is more general, and dynamic is only its special case.

A state in quantum mechanics, as already mentioned, is characterized by a wave function, and the Schrödinger equation uniquely connects wave functions at different moments in time. Rejecting for the microcosm the dynamical-type ambiguity that exists in classical mechanics and electrodynamics, quantum mechanics exhibits probabilistic-type ambiguity, which is valid here to the same extent as for the objects of classical statistical theories.

All that has been said about causality is still quite reasonable. Let us now make one last remark, which is in the nature of an assumption, the validity of which can hardly be substantiated convincingly at the present time, namely: exactly quantitative probabilistic causality formulated in classical statistical theories does not completely exhaust causality. In addition to it, the concept of qualitative causality is preserved, which means that certain random values of coordinates, impulses and other quantities are causally determined. For example, the reason for another random movement of a Brownian particle in a certain direction is the friendly collision of the molecules of the particle from one side.

It is quite obvious that the presence of probabilistic causality in classical statistical mechanics, the impossibility of unequivocal predictions of the values of coordinates and impulses do not mean the impossibility of qualitatively establishing what exactly is associated with the difference in the behavior of individual objects of a system located in fixed microscopic conditions. All this, of course, is true, provided that the dynamic law for the movement of an individual object, such as a Brownian particle, does not make sense. It is not possible to completely exclude in advance the possibility that in quantum mechanics qualitative causality is still able to explain the details of this or that behavior of a micro-object. Certain deviation of the electron during diffraction, decay of particles at the moment, etc. have some qualitative reasons.

### 3.5. Questions and tests for self-testing of knowledge

1. What is determinism?

2. How are determinism and causality related?

3. Does mechanical determinism work in the microcosm?

4. How are probabilistic determinism and causality related?

5. How are dynamic and statistical laws related?

6. Specificity of Laplace's determinism.

7. What are the general indicators of statistical laws?

8. The role of dynamic and statistical laws in understanding the essence of determinism.

9. The quantum-relativistic picture of the world does not include:

a) a model of the world-thought, based on the ideas of general connection, variability and development;

b) knowledge is relatively true;

c) activity style of thinking;

d) life is a natural result of the self-development of matter;

e) all provisions are correct.

10. Why would a space object, having crossed the Schwarzschild horizon, never reach the surface of a black hole?

a) because the principle of determinism does not work;

b) because God's providence works;

c) because time stands still;

d) because this is prevented by the theory of the duality of matter;

e) all statements are incorrect.

11. Experiments of "delayed quantum erasure" and superposition

a) confirm the materialist position, since all this exists outside the subject and is perceived by him;

b) are manifestations of God's providence;

c) are insufficiently researched;

d) have a subjective-idealistic nature.

## Topic IV. Philosophical and methodological problems of cosmology

### 4.1. Philosophical foundations of cosmological models

Cosmology is an astrophysical theory of the structure and dynamics of changes in the Metagalaxy, which includes a certain understanding of the properties of the entire universe. Cosmology is based on astronomical observations of the Galaxy and other star systems, the general theory of relativity, the physics of microprocesses and high energy densities, relativistic thermodynamics, and other new physical theories.

Judgments about the properties of the entire universe are a necessary component of cosmology. Like any fundamental science, cosmology includes a system of philosophical foundations: worldview and methodological principles about the properties and laws of the surrounding world and methods of its cognition, ways of explaining empirical facts. These foundations were historically formed under the influence of various philosophical concepts, between which there was and continues to be a fierce struggle in the understanding of the world.

After these preliminary remarks about the subject of cosmology and the complexities of its research object, let's move on to a brief description of the most important achievements of modern science in the knowledge of the structure and development of matter on a gigantic cosmic scale.

Initially, it was assumed that the Metagalaxy is one of the largest cosmic systems in which galaxies are concentrated, and on an even larger scale, the Metagalaxies themselves are distributed in space more or less homogeneously and evenly over any large distances. The photometric and gravitational paradoxes in this model were eliminated by the assumption of intergalactic matter, which absorbed light and gravity and transformed them into other forms of matter.

The general theory of relativity (GRT), created by A. Einstein, allowed a new approach to the development of models of the large-scale structure and evolution of the universe. ZTO connects gravity with the curvature of space-time, considering them as two inseparable sides of physical reality. Heavy masses due to the gravitational field cause "distortion" of space-time, and the latter, in turn, affects the movement of bodies, which occurs along geodesic lines. Einstein's gravitation equations relate the curvature of spacetime to mass density, mass momentum, mass flow, and momentum flow. On the basis of these equations, Einstein developed the so-called "static" model of the universe. This model was based on a philosophical assumption about the homogeneity of the distribution of 267 galaxies in the space of the Universe and the stationarity of the universe in time.

Since gravitational forces act everywhere in the form of attraction and should cause the concentration of scattered matter into a single dense mass over time, in order to balance gravity and ensure the stationarity of the universe, Einstein introduced the so-called lambda term into the equation of gravity, which is equivalent to the postulates of cosmic forces of repulsion of an unknown nature, which are increasing with the distance between the bodies and balance the forces of gravity. But even in this way it was not possible to achieve a picture of complete static in the Universe.

Changes in the density of the distribution of matter on a fairly large scale due to the movement of galaxies caused a violation of statics, which culminated in the concentration of matter, then its dispersion. In 1922, the Soviet mathematician A. A. Friedman managed to find another solution to the ZTO equations, abandoning the assumption about the static nature of the universe, but accepting the assumption about the homogeneity and isotropic distribution of matter. A. A. Friedman's solution to the gravity equations showed that the universe is non-stationary and its space has a time-varying curvature that is the same on all small scales. At the same time, A. A. Friedman allowed three possible consequences from the solutions he proposed: the universe and its space expand over time; the universe is shrinking; in the universe, cycles of compression and expansion alternate after long intervals of time.

In 1926, the American astronomer Hubble discovered a red shift of the spectral lines while studying the spectra of distant galaxies, which was interpreted as a consequence of the Doppler effect and evidence of the mutual distance of galaxies from each other at a speed that increases with distance. According to recent measurements, this increase in the rate of expansion (the Hubble constant) is about 55 km/s for every million parsecs. After this discovery, A. A. Friedman's conclusion about the non-stationarity of the universe was confirmed, and the model of the expanding universe was established in cosmology. An additional strong argument in its favor was the discovery in 1965 of equilibrium relict radio radiation, which, according to Planck's law, corresponds to a temperature of 2.7/C. It is considered as a distant consequence of the primary grandiose explosion that gave birth to the universe we observe. More than 20 billion years ago, all matter of the universe was in a singular state — in a point volume with infinite density. The model does not explain how it appeared there, but it is assumed that as a result of the gravitational collapse of all matter, the destruction of all atomic nuclei, elementary particles and other possible micro-objects and the compression of matter into a point with infinite mass and density occurred.

The causes of the singularity, the nature of matter staying in this state, as well as the causes of the big bang and the transition to expansion in all models of the "hot universe" are considered unclear and beyond the scope of any modern physical theory. But if there was such an explosion, then the picture looks like this. After 10-43 seconds from the beginning of the expansion from the singularity (Planck moment), the birth of particles and antiparticles began, then after 10-6 seconds - the appearance of protons and antiprotons and their annihilation. The number of protons by one hundred millionth part (10-8) exceeded the number of antiprotons, as a result of which the substance from which all galaxies, stars and planets arose was preserved after annihilation. If the number of protons and antiprotons were equal, the substance would completely transform into radiation, and it would be impossible for the entire observable cosmos and the Earth to arise. 1 second after the beginning of the expansion, electron-positron pairs began to be born and annihilated, after 1 minute, nuclear fusion and the formation of deuterium and helium nuclei began. The fate of the latter accounted for approximately 30% of the mass of the remaining protons, which agrees with the concentration of helium observed in space. The formation of heavier elements cannot be explained within the framework of this theory, since there is not enough time for their synthesis during the expansion process. These elements are formed at the next stage of the evolution of stars as a result of thermonuclear reactions in their interior, and heavy elements are synthesized during supernova explosions and then ejected into interstellar space, where they eventually concentrate in gas-dust clouds, from which second-generation stars of the type of the Sun and the planets around them are formed them 300,000 years after the Big Bang, radiation separated from matter, the universe became transparent, and in the following billions of years, galaxies, primary stars in globular clusters, and second-generation stars in spiral arms of galaxies began to form. The earth appeared 4.6 billion years ago, and life on it - about 3 billion years ago.

In the very initial moments of expansion, when the temperature in the "hot" universe reached 1031 degrees and the pressure was incredibly high, primordial black holes appeared with different sizes - from 10-15 cm to several kilometers, but with masses from thousands of tons to the masses of large stars . Black holes with very small sizes then disintegrated, and large ones can still exist and be the cores of galaxies or quasars.

Relict radio radiation coming to Earth isotropically from all directions is considered as a result of separation of radiation from matter several hundred thousand years after the explosion.

The further picture of the evolution of the universe is drawn ambiguously in various cosmological models. If the average critical density of matter in the universe is less than 6-10~30 g/cm3, then the expansion of the universe will continue indefinitely. If it is greater than this value, then the expansion will be replaced by compression, then by gravitational collapse and the transition to a singularity. Theoretically, pulsations with an increase in the radius of the universe as a result of the transition of matter into radiation, an increase in the entropy of the system, until the radius, after many cycles of pulsations, leads to unlimited expansion.

Since we know nothing about the behavior of the universe beyond our immediate surroundings of light-years, obviously no model can help determine the point in time when the expansion of the real universe began with sufficient precision.

We can only roughly estimate that the duration of the expansion of the region closest to us may be 109-1010 years.

On the way from elementary particles with dimensions of 10 14 cm to the postulated minimum gravitational length of 10-33 cm lies an inexhaustible variety of new physical theories and discoveries that can fundamentally change our understanding of the microcosm and the universe. But the creation of a theory of the development and structure of the universe requires a much larger amount of reliable information and a consistent integration of all future astrophysical theories.

In the big bang model of all matter, the causes of the explosion are also unclear, and the energy released during it cannot be explained by any laws of physics.

Extremely distant galaxies have now been discovered, the red shift of which corresponds, according to the Doppler effect, to a speed of mutual distance of 150,000 km/s, and apparently this speed increases even more, approaching the speed of light, until the galaxies disappear beyond the horizon of fundamental observability. Such monstrous kinetic energy, compared to the rest mass energy of galaxies, cannot be deduced from any physical laws.

Contradictions also arise in the explanation of the phenomenon of expansion itself. If the expansion is a valid physical process, it occurs due to the "invasion" of the Universe (which is expanding) either into the vacuum of the pseudo-Euclidean space or into the space of other cosmic systems of the Universe. The existence of an absolute vacuum cannot be allowed, because space is an attribute of matter and does not exist outside of it. It remains to recognize the expansion into the inner space of other material systems, which can both contract and expand, developing according to their own laws. But then the modern cosmological theory will cover only the Metagalaxy. Only philosophical-materialistic principles in the system of its foundations can be extrapolated to the entire universe, as well as some general physical laws such as fundamental laws of conservation, principles of symmetry, and the principle of variation.

It is possible, however, to take a different point of view and assume that the expansion of the universe is really taking place, but no outer space and other cosmic systems exist; it's just that space itself seems to be created in the process of expansion of the universe, in the sense that over time the distance between any points increases and the geometry of space changes. A similar conclusion followed from the solution of the gravity equations developed by A. A. Friedman and was repeatedly reproduced later in the literature. However, such a point of view contains internal contradictions. Space is a general attribute of matter, it expresses the extent and structure of all existing material systems. If there was an expansion of space itself, which was given the sign of substantiality thanks to this, then over time there would be an increase in the size of all material systems: elementary particles, atoms, molecules, planets, stars, galaxies, etc.; and in the same proportion as the distance between galaxies increases. Meanwhile, nothing like this happens in the world, the sizes of specific material systems (from galaxies to elementary particles) do not increase according to Hubble's law. It follows from this that there is no expansion of space, there is expansion only on the scale of the Metagalaxy, and it is possible only in the outer space of other material systems. But this, however, does not exclude the search for alternative theoretical explanations of the causes of the redshift, different from the model of the Big Bang and the expanding Universe.

In the literature on cosmology, the opinion was expressed that various cosmological models of the universe, put forward on the basis of the solution of the universal gravity equations, can characterize not only our one universe, but different states of the universe in different periods of its existence in the past and future, similar to the potentially possible worlds in the concept of Leibniz. Everything that is not prohibited by the laws of nature can be realized anywhere and anytime. In principle, such a possibility is not excluded if these are valid laws of the objective world. But one should distinguish between objective laws of nature and theoretical expressions of these laws in science. The latter are always an approximation to the former, and some of the models of the universe, based on idealizations and not fully proven postulates, may even contradict the objective laws of nature, both known today and those that will be formulated in theory as a result of future refinements of known laws. Therefore, not every theoretical model can have an objective analogue in nature. Some models only show different theoretical approaches in idealizations.

All that has been said makes it possible to emphasize once again the extreme complexity of developing a theory of the large-scale structure and evolution of the Universe.

### 4.2. Philosophical problems of the theory of space and time. Black holes

In the theory of Faraday and Maxwell, light, electricity and magnetism were united as manifestations of a single electromagnetic field, but the latter was still considered as a structural feature of the all-pervading ether. The propagation of gravity and electromagnetic waves in the ether was interpreted as close action, the transmission of disturbances from point to point. This understanding of interaction and space, which developed within the framework of classical physics, was inherited and further developed within the framework of the theory of relativity and quantum mechanics in the 20th century, after the collapse of the ether hypothesis. The aether turned out to be unnecessary, and electromagnetic and gravitational fields began to be considered as material entities. A. Einstein wrote: "Empty space, that is, space without a field, does not exist. Space-time does not exist by itself, but only as a structural property of the field." This view was a physical specification and confirmation of a rational understanding of space and time. Space and time are attributes of matter and are determined by its connections and interactions.

In the literature, it is very common to claim that the changes made by the theory of relativity to our ideas about space and time are connected with their unification into a single four-dimensional continuum. However, this is not entirely correct. First, a single continuum is possible, as A. Einstein pointed out, in classical physics and its difference from the relativistic four-dimensional continuum consists only in the possibility of drawing a clear boundary between spatial and temporal dimensions. Secondly, space and time were combined into a single entity even before Newton (Cambridge Neoplatonists) and after Newton, before Einstein - Hamilton's theory of quaternions. Thirdly, Einstein himself believed that not the four-dimensional formalism of Minkowski, but the new relational interpretation of space and time represents the main content of the theory of relativity. However, it would be wrong to underestimate the enormous contribution made by the theory of relativity to the revolutionary changes in ideas about space and time in the physics of the 20th century.

According to the special theory of relativity, the spatio-temporal properties of bodies depend on the speed of their movement. Spatial dimensions are reduced in the direction of movement when the speed of the body approaches the speed of light in a vacuum (300,000 km/s), and temporal processes slow down, as if time slows down in fast-moving systems.

But being in a companion frame of reference, that is, moving parallel and at the same distance from the system being measured, relativistic effects cannot be observed, since all spatial scales and clocks used in measurements will change in the same way. According to the principle of relativity, all processes in inertial systems proceed in the same way. However, if the system is non-inertial, i.e. moving with accelerations and decelerations, then relativistic effects can be observed and measured. So, if an imaginary relativistic ship of the type of a photon rocket goes to distant stars, then after its return to Earth (or Earth orbit), the time in the system of the ship will be much less than on Earth, and this difference will be the greater the further the flight takes place, and the speed of the ship is closer to the speed of light. In principle, the difference can be measured even by hundreds or thousands of years, as a result of which the crew of the ship is immediately transferred to the near or more distant future, bypassing the intermediate time, since the rocket together with the crew turned off from the course of development on Earth.

New aspects of the dependence of space-time relations on material processes were revealed in the general theory of relativity. This theory brought the physical foundations of non-Euclidean geometry and connected the curvature of space and the deviation of its metric from the Euclidean one with the action of gravitational fields created by the masses of bodies. The general theory of relativity is based on the principle of equivalence of inertial and gravitational masses, the quantitative equality of which was long established in classical physics. Kinematic effects arising under the influence of gravitational forces are equivalent to effects arising under the influence of accelerations. So, if the rocket takes off with an acceleration of 2g, then the rocket crew will feel as if they are in twice the gravitational field of the Earth. If the spaceship enters a stationary orbit, then inside the ship all bodies will be in weightlessness, as if the Earth's gravitational field has completely ceased to act. Based on such facts, it is often said that the gravitational field is equivalent to the field of inertial forces. However, the equivalence here is only for some kinematic effects, in fact, the nature of these fields is completely different. The gravitational field is a special form of matter created by all material bodies, and it is not destroyed by any transformations of reference systems. Although the field of inertial forces is not a fiction, it is also not a form of matter, but an expression of certain manifestations of the inertia of bodies, similar to how they talk about stress fields that arise in metal under heavy load or about a sound field in a certain audible zone. Any material field and its quanta can transform into other material particles under certain conditions. Fields are theoretically compared to the distribution in space of various properties or forces that cannot be transformed into material particles, they always change only into other properties or forces. Therefore, one cannot talk about the complete physical equivalence of the gravitational field and the field of inertial forces.

Based on the equivalence of inertial and gravitational masses and related kinematic effects in the theory of relativity, the principle of relativity was generalized. In classical physics, this principle asserted the covariance (invariance of form) of the laws of mechanics in all inertial frames of reference. In the special theory of relativity, this principle was also extended to the laws of electrodynamics, and the general theory of relativity affirmed the covariance of the laws of nature in any frame of reference, both inertial and non-inertial.

The theory of relativity established both the distortion of space under the influence of gravitational fields and the slowing down of time in strong gravitational fields. The latter manifests itself, in particular, in the gravitational shift of spectral lines in the spectra of white dwarfs and quasars, due to the fact that the natural frequency of photons emitted by atoms from the surface of these massive objects is lower than the frequency of quanta emitted by atoms that make up the objects that are outside the gravitational fields or in weak fields. But in connection with the establishment of interdependence between the gravitational field and the metric of space, concepts that turn the relationship of matter and space upside down, that consider space as a special kind of substance, primary in relation to matter, have revived again. Einstein shared these views. His views on the relationship between matter, space and time were quite controversial. In the first period of his work, when creating the special and general theory of relativity, A. Einstein correctly emphasized the attribute nature of space and time, the impossibility of their existence without matter. But in the future, during the development of geometrized versions of the unified field theory, he was inclined to the substantialization of space. The basis for this was the formal interpretation of the gravitational field as a manifestation of the curvature of the space-time continuum. Then Einstein tried to combine the gravitational and electromagnetic fields within the framework of some single field, but it was also understood by him as a manifestation of the curvature of the space-time continuum. In 1930, he wrote: "We come to a strange conclusion: now it seems to us that space plays the primary role, matter must be obtained from space, so to speak, at the next stage. Space absorbs matter. We have always considered matter as primary and space as secondary. Space, figuratively speaking, is now taking revenge and "eating" matter." Later, similar views were developed by J. Wheeler within the framework of geometrodynamics, put forward as a new unified theory of matter, space and time. J. Wheeler believed that "there is nothing in the world but an empty curved space."

Matter, charge, electromagnetism and other fields are only manifestations of the distortion of space. Physics is geometry.

However, all attempts to reduce matter to space did not lead to any proven results, primarily due to the failure of their philosophical foundations. Already in the 1930s, new elementary particles — neutrons and mesons — were discovered, and later the list of elementary particles expanded immeasurably, the theory of nuclear forces, quantum chromodynamics, etc. developed. All these new physical discoveries and theories cannot be squeezed into the framework of formal geometrized constructions, from which no specific parameters of particles and fields and no non-trivial predictions can be deduced. On the contrary, all new experimental data and physical theories based on them testify that space and time are not primary substances, but integral attributes of matter, forms of its existence, and their properties depend on material relations. The detection of universal properties of space and time is associated with great difficulties and extreme extrapolations of the general laws of the movement of matter. Any considerations on this reflect the existing level of our knowledge and may undergo significant changes in future theories according to the dialectic of relative and absolute in scientific knowledge. But since knowledge develops along the lines of the continuity of objective truths and the integration of the reliable content of scientific theories, it can be safely assumed that many modern statements about the general properties of space and time, tested and confirmed by practice and the evidence system of modern theory, will retain their significance in the future scientific picture of the world.

Likewise, the temporal relations characteristic of the virtual processes of interaction of particles with their own field, for the internal virtual states of quarks and antiquarks in a stream of elementary particles can be completely unusual from the point of view of not only classical but also quantum physics. The development of modern science takes place along the lines of a constant decrease in the share of visual representations associated with macroscopic experience, and the growth of non-visual and abstract content, which reflects the quantitative and qualitative infinity of the material world.

When moving to megaworld systems, we are also faced with qualitative changes in the properties of space. The space of black holes is relatively closed for light rays and particles of matter moving inside the photosphere of a black hole. It is finite in volume, but limitless in the sense that light rays do not encounter boundaries anywhere, but move in closed lines. However, this movement cannot be long because of absorption and re-emission processes. The space of a black hole will not be completely closed, since there is constant accretion (absorption) of external matter, the black hole interacts with other bodies through the gravitational field. In addition, the matter of a black hole can gradually evaporate into outer space as a result of tunnel transitions of microparticles.

The central regions of supermassive objects and black holes can have such spatio-temporal properties that modern science is unable to imagine. The concept of a singularity in the general theory of relativity – an object with infinite density, a gravitational field and point dimensions – indicates the specificity and unusualness of the space of such objects, but most likely characterizes the limits of the application of modern physical theories and the need to move to qualitatively different physical concepts .

Let us now consider the general and specific properties of time. The general properties of temporal relations of all material systems include: objectivity of time, its inextricable connection with movement, space and other attributes of matter, duration, eternity, unity of the intermittent and continuous, one-dimensionality, irreversibility, unidirectionality and heterogeneity.

The question of how the past, present and future are related in their being is of scientific importance. The past was transformed during changes into subsequent states of matter, which may be qualitatively different from the previous ones. In this case, the past really no longer exists, but there is only the present in the form of coexisting and interacting material systems. The future also does not physically exist, it has yet to arise with the help of the transformation of the current states of matter into it. But in real existing systems there are some possibilities of future events arising from the laws of their movement and development. However, not all the possibilities of future phenomena precede the present, because the possibilities themselves also arise in the process of development, and the possibilities that have not been realized disappear, being replaced by new ones. There is no unequivocal determination of the future in the world, determination has a probabilistic character.

What are the reasons behind the asymmetry and irreversibility of time? The literature has repeatedly tried to connect the "arrow of time" with certain physical laws and processes: the growth of entropy in all material systems, the expansion of the universe, or with causal relationships. All these processes contribute to the general irreversibility of time. But the basis of the irreversibility of time should be sought not in any partial physical processes, but in equally fundamental attributes and laws of the existence of matter, which are found at all structural levels. Entropy growth, according to the second law of thermodynamics, occurs everywhere on a macroscopic and cosmic scale. But in the microcosm, a local decrease in entropy is possible due to fluctuations in the density of the distribution of particles, but it does not occur in reverse time, since the law of causality is not violated here.

The expansion of the Metagalaxy cannot be the reason for the irreversibility of time, because all the reverse processes of compression of cosmic systems and gravitational collapse occur with the usual passage of time. Reverse time would mean the backward movement of all development processes in the world and causal relationships, which would lead to an increase in entropy and a violation of the law of causality. The irreversibility of time is due to the fulfillment of the specified laws, the general irreversible process of change and development of matter.

The irreversibility of time, the non-equivalence of the past and the future are increasingly recognized by various sciences, which are permeated by the concept of development. Accounting for this irreversibility is becoming increasingly important in modern physics. Previously, it was believed that physical laws are invariant with respect to changing the sign of time, since time in the equations of motion of classical and quantum mechanics is squared. This suggested that all physical processes can occur in the same way both forward and reverse, at least in the microcosm, where the law of increasing entropy does not directly determine the interaction of elementary particles. However, in recent years, processes have been discovered that demonstrate the irreversibility of changes in the microcosm: the decay of unstable particles (neutrons, mesons) with neutrino radiation, which have a pronounced asymmetry. It has been established that protons can decay over a period of about 1031 years. All existing varieties of elementary particles are not eternal, but arose at a certain stage of the historical progress of matter. In the future, however impossibly distant, they may be replaced by qualitatively different forms of mother in local regions of the infinite universe.

In relation to time, such properties as the specific duration of the existence of material systems from their origin to their disintegration, the rhythms of their processes, the relationship between cycles of change, the speed of the processes, the pace of development and the relationship between the paces at different stages of evolution are specific. With an increase in the speed of movement of bodies and in powerful gravitational fields, a relative slowdown of all processes in bodies occurs, their own time seems to be shortened in relation to the time of external systems.

The finiteness of the speed of propagation of interactions determines the relativity of simultaneity in different systems. Events that are simultaneous in one system may be non-simultaneous with respect to another system that is moving relative to the first. All this leads to the fact that the universe lacks a single time, as well as a single space.

In all biological and social systems, the above general properties of space and time and most of their general properties are manifested. The relationship between the spatio-temporal properties of physical, biological and social systems is not at all the same as between the forms of their movement. Here there is much more unity than differences, because the spatio-temporal relations of each small system are included as components in the spatio-temporal relations of a larger-scale system, and are inextricably linked and conditioned with them. It is also necessary to keep in mind that every living organism consists of atoms, molecules, elementary particles and fields. Their spatio-temporal properties and relationships determine the spatio-temporal properties of living matter. Thus, one could talk about a special biological space of a living organism, if biological connections and forms of movement create a special structure and metric of space in a living organism, as is expected in black holes or in the structure of elementary particles. But the electromagnetic connections that determine chemical processes in living matter have too little energy to produce such fundamental differences in the properties of space. In the same way, one could talk about a special biological time in a living organism, if, under the influence of biological forms of movement, there was a slowing down of atomic vibrations and all cyclic processes in the microcosm in comparison with the same processes in inorganic bodies in the environment.

But this is not really the case. The energy of electromagnetic connections in living matter is too weak for such changes, for this, superpowerful gravity fields or movement speeds close to the speed of light are required. As for biorhythms and various cyclical processes in living organisms, such specific cycles exist in all systems, but they are insufficient to construct some special biological time. Spatial and temporal relations in biological and social systems reveal unity and difference with analogous relations in other material systems. This "status" of theirs reflects the general unity and structural heterogeneity of matter.

In conclusion, let us emphasize that the infinite in the world manifests itself in the following aspects:

- in the structure of matter, in the existence of an infinite variety of types of material systems and their corresponding structural levels;
- in the spatial properties and relations of these material systems;
- in the time of their change and development, in the quantitative and qualitative indestructibility of development;
- in the infinite variety of properties, connections and interactions of matter.

**4.3. Questions and tests for self-testing of knowledge**

1. What is a singularity?
2. The essence of A. Einstein's special and general theory of relativity.
3. What is entropy?
4. How to understand the expression "infinity and eternity of matter"?
5. Does "dark matter" exist?
6. Does absolute space exist (free from particles of matter)?
7. What is the essence of the discovery of the American astronomer Hubble?

8. 6. Why will a space object, having crossed the "Schwartzschild horizon", never reach the surface of a black hole?

a) because the principle of determinism does not work;

b) because God's providence works;

c) because time stands still;

d) because this is prevented by the theory of the duality of matter;

e) all statements are incorrect.

9. Heat death of the universe" is impossible because

a) the universe is renewable;

b) antimatter exists;

c) there is eternity;

d) the universe is an open system;

e) all answers are correct.

# Topic V. Problems of the philosophy of technology: methodological aspect.

### 5.1. Philosophy, science, technology: a general overview

The specifics of the interaction of science and technology. The interaction and mutual influence of science and technology are obvious. The tendency for science to focus primarily on production, on the development of technical ideas, is combined in the reverse process - science receives from production a powerful impulse for its own development in the form of technical equipment. Interaction between science and production becomes not only direct, but also necessary - both for technology and for science. After all, many scientific ideas, which were previously considered as hypothetical, were able to be confirmed as a result of the development of the technical and technological capabilities of society. The path from a scientific idea to its implementation in a technical device has shortened significantly. In fact, many research centers began to look for ways to bring their new achievements closer to direct production.

Technical systems form the "technosphere" - the area of man-made artificial systems. The technosphere is a sphere that contains artificial technical structures that are manufactured and used by humans. There are:

-a part of the biosphere (and, it is thought that in the future the entire biosphere), which is radically transformed by a person with the help of the indirect influence of technical means for the sake of better compliance with its social- and economic needs and increasing the comfort of society's life;

- the most complex part of the anthroposphere, which includes the technical means of production and the natural resource potential of the territory in their interaction based on the achievements of scientific and technical progress;

- practically closed - initially a regional, and in the future, a global technological system of utilization and re-utilization of natural resources involved in economic turnover, designed to isolate economic and production cycles from the natural metabolism and flow of energy - which means the reduction of negative mutual influence.

The technologic sphere is a complete system that includes:

 - the technical artifacts themselves, i.e. technology as an object in its social- and cultural context;

 - specific technical knowledge, skills, rules, theories, their cultural value;

- technical activity;

- specific techno-mentality;

 - a system of relations between man and nature, where technology acts as a certain mediator.

Thus, the development of modern society can be called technogenic to a large extent, since it is already determined by the achievements of the technosphere, the use of its transformative capabilities.

*Specificity of natural and technical sciences.* Currently, among scientists and philosophers, there is no unanimity in the analysis of the issue of the connection between natural and technical sciences. Technical sciences are often equated with applied natural sciences, but in the conditions of modern scientific and technical development, such an idea does not correspond to reality. Today, more and more philosophers agree that technical and natural sciences should be considered as equal scientific disciplines. Although technical science serves technology, it is primarily a science aimed at obtaining new, objective knowledge and its dissemination. Research engineers in the laboratories of industrial firms and corporations, scientists in technical universities and academic centers make scientific breakthroughs and technological discoveries. Technical and natural sciences have the same subject area, which is studied with the help of technical devices from a different angle of view. In the natural sciences, the technical component in experimental equipment has a decisive role.

Most physical or chemical experiments are artificially created situations. Objects of technical sciences also represent a kind of synthesis of "natural" and "artificial". The artificiality of objects of technical sciences lies in the fact that they are products of conscious purposeful human activity, and their naturalness is manifested in the fact that all artificial objects are ultimately formed from natural material. Experiments in the natural sciences are artifacts, and technical processes are modified natural processes. An experiment is an activity for the production of technical objects, which can only be considered partially engineering, since scientists construct machines to continue scientific research, that is, to obtain new scientific knowledge about nature.

From the natural sciences to the technical sciences, the main original theoretical propositions and concepts are transferred, as well as the ideals of science, the setting for the theoretical organization of scientific and technical knowledge, and the development of ideal models are borrowed. At the same time, in technical sciences, everything borrowed is significantly transformed, resulting in a new type of organization of theoretical knowledge. In addition, technical sciences, for their part, greatly stimulate the development of natural sciences. But today, ascertaining this state is no longer enough.

It is now commonplace for targeted research conducted in industrial laboratories by researchers trained in engineering to lead to major scientific breakthroughs, or for scientists working in universities or academic centers to make important technological discoveries. Therefore, technical sciences should be fully considered as independent scientific disciplines. At the same time, they differ significantly from other sciences in the specifics of their connection with technology.

Identification of the specifics of technical sciences is usually carried out on the basis of their comparison with other sciences - natural sciences, social humanities, and mathematics. The main specific feature of technical sciences is due to the fundamental difference between technical and technological regularities and natural ones, which are the subject of study of natural science. The fact that the basis of the functioning of technologies are laws revealed by natural science does not at all indicate that these laws in a generalized, abstract, natural form can serve as a sufficient basis for the creation, description, and research of artificial technological objects.

Technical objects are real objects that are created to perform certain appropriate functions. Technology, being an object of creativity, is not a simple implementation of natural scientific knowledge: it has its own specific laws of development, which are also the basis of technical creativity. Moreover, the laws revealed by natural science serve only as a starting point for technical creative activity.

The action of general laws of natural science manifests itself in a specific form, due to the fact that the real conditions of their functioning impose a lot of limitations of the design, technological, economic, and aesthetic plan. Technical regularities reflect a specific form of manifestation of natural laws, due to a stable, purposeful, artificially organized interaction of natural processes, which allows the use of the power of nature in a suitable, safe form for humans.

The specificity of the cognitive activity carried out in the process of creating technological objects is determined by the fact that it is aimed at identifying structural and functional dependencies and inventing (designing) based on them structures that perform given functions. Therefore, in order to materialize in technical objects, natural laws must be transformed into technical laws.

The development of natural sciences is a necessary but not sufficient condition for the creation of new technologies. That is why, in order to set and successfully solve modern technological tasks, a necessary precondition is the study of not only the processes of nature and the discovery of laws, but also the study of the heterogeneous conditions of the action of these laws themselves.

The specifics of the philosophy of technology. The philosophy of technology is an in-depth knowledge of such a phenomenon as technology (we will immediately agree that it is more correct to say "philosophy of science and technology", but in the West the name "philosophy of technology" prevails, so we will use this name). Philosophy is related to technology primarily through the philosophy of science - however, this discipline is one of the youngest branches of philosophical knowledge. As a separate field, the philosophy of technology was singled out around the middle of the 20th century. For a long time before that, philosophy was engaged in its own fundamental tasks, since philosophers believed that the problems of technology were too concrete, derivative, and therefore not worth attention. A real broad interest in the philosophical interpretation of technical problems began with the World Philosophical Congresses in Vienna (1968), Varna (1973) and Düsseldorf (1978). From that time, the number of printed works devoted to this problem began to grow rapidly, although even now there are doubts about the feasibility of a philosophical understanding of technical problems. We consider such statements to be illegitimate, moreover, the introduction of the technical field into the circle of interests of philosophy is even somewhat late. The fact is that the narrowly utilitarian approach to technical activity from the very beginning (modern era, 12th century) caused an ambivalent development of events in the future - on the one hand, it led to grandiose successes in almost all areas of social life, to a sharp increase in the comfort of life for the masses people, but on the other hand - even then he "predicted" the gradual formation of the future global ecological crisis, one of the main causes of which is the so-called "demonism of science". And the "contribution" of philosophy here is significant - its contempt for nature ("nature is a storehouse from which you can draw without measure and without calculation" - F. Bacon, 12th century) is precisely one of the main causes of the phenomenon, which can really lead to the end of human existence. The key mistake was not taking into account the extremely wide "halo" of social and cultural consequences from the seemingly "narrow" use of technology (which we will talk about in more detail below).

Let us single out more specific reasons for the formation of such a branch of the philosophy of science as the philosophy of technology:

- science and technology are currently the most important spheres of human activity in terms of influence and results;

- the development of science and technology manifests itself in all aspects of society's life, at all its levels, and causes its radical changes;

- In the XX-XXI centuries. the rapid development of science and technology significantly expanded the area of their influence on society: fundamentally new aspects of their connection with various spheres of human activity were revealed:

with the progress of history, with human nature, and at the same time new aspects of human existence were discovered;

- modern philosophy has realized a certain "inferiority" of its own: the lack of involvement in the interests of philosophy of new areas of reality somewhat impoverishes the basis for solving certain traditional problems and philosophy itself, for example: what is a person, what is nature, the specificity of new relationships between them, a whole complex social problems. This includes social- and cultural factors: knowledge, environmental, ergometric and psychological aspects of human technical actions.

Today, the philosophy of technology is a branch of philosophical knowledge, the subject of which is the study of both the technology itself and its impact on the life processes of an individual and society as a whole. With the help of technology and through its influence, the specifics of human social life, culture, science are analyzed - both in the era of scientific and technical and information technology revolution, into which it has gradually evolved; the problems of self-preservation of civilization and spiritual self-worth of the individual caused by them are analyzed - while preserving a positive asset without which modern humanity can no longer imagine its life.

All representatives of the philosophy of technology are divided into two large camps - they can be conventionally called the camp of pessimists and the camp of realists. More details:

- the position of the camp of conditional pessimists was quite clearly articulated by Martin Heidegger: he considers technology as one of the main factors of the deep crisis of our culture, civilization, a special "disease" of culture, its active "disease". Technology also "appears" among supporters of this camp as one of the main reasons for the total destruction of nature, the destruction of various social processes, moreover, it is emphasized that even the person himself gradually becomes only a functional "screw", a technical element in the functioning of the global complex technosphere;

- the second camp - the camp of conditional realists - in the philosophy of technology demonstrates a more realistic position. Technology is our inevitability, it is the destiny of our civilization. At the same time, the position of the first camp is not refuted (because it is quite difficult to do this), but it is rightly emphasized that, whether we like it or not, we were born with technology and we will die with it. Therefore, the only way out is seen in a specific dynamic conformism, without much hope for a final victory.

A rather specific theoretical-emotional, pessimistic-realistic "mixture" for optimizing the situation and solving this problem is offered by the policy of the Green Party - the total environmentalization of the planet through the rejection of modern technology. But currently this policy has two significant flaws:

- philosophy points to the first: humanity functions by constantly solving the dilemma between new needs and the impossibility of satisfying them at the moment. It is this contradiction that motivates and stimulates progress. And if we take into account the immanent, innate targeting of needs for constant growth (recall, a) the famous remark of K. Marx in "Capital" that there is no such crime on Earth that a person would commit to for the opportunity to have a 300% profit; b) no less well-known is the first truth from the Buddha's "four noble truths" that the constant cause of human suffering is the "gap" between the possible and the desired - a person always wants more than he can and, again, is ready for the sake of what he wants or not everything ), we come to a sad conclusion - even understanding the criticality of the ecological global situation, humanity will not agree to lower the level of comfort of life that technology and technology provide it today. We draw an interim conclusion: "green" policy can achieve success only when it finds a formula for solving the problem of ever-increasing human needs not at the expense of the development of technology, as is happening now, but at the expense of the total environmentalization of the planet and implements it in life - realistically and globally. Such a formula (or theory, or algorithm) has not yet been found, therefore there is no planetary ecological optimization program either (as evidenced by the constant failures of periodic world meetings). The attempts of the "greens" to solve this problem are partially, as we observe, palliative, they are successful, but also partial and temporary;

- concrete scientists point to the second mistake in solving the problems of the ecological crisis. Pessimistic forecasts regarding finding an algorithm for the process of greening the planet are currently increasing due to scientists' calculations of the cost of the (non-financial) material and technical base and the production of various ecological installations. It turned out that the damage to the environment during their manufacture, starting with the extraction of minerals, sometimes significantly exceeds the degree of environmental protection of the planet by these installations.

**5.2. Circle of problems of the philosophy of technology. Environmental crisis.**

Currently, it can be stated that the damage to the environment of the planet due to the excessive use of modern technical means is undeniable, and the work to protect the environment within the framework of the entire planet is necessary. But escape from modern equipment and technologies, return to natural forms of economy, economy, etc. can mean the same end of anthropos as the result of a planetary ecological crisis - let's take as an example the situation with diseases and methods of their treatment in modern medicine and in the medicine of the Ancient World. That is, the radicalization and absolutization of today's ways of solving environmental problems and their spread to the future as the only possible, unequivocal is unacceptable. We have a long strategic path ahead of us to only partially optimize the state of the environment (we choose the optimal from the possible) - both because this process has an objective-subjective nature (the negativism of subjective intervention in the optimization process is undeniable), and because we have already missed the start of environment optimization.

Let's explain what is meant by the example of the analysis of the global environmental situation by the Club of Rome (an international public organization, an analytical center for global problems, created in 1968).

In the first report to the Club of Rome, "Limits to Growth" (1972), D. Meadows stated that the limits of growth not only exist, but also today require drastic measures to, if not prevent them, at least remove them. The Club of Rome used simulation modeling to conclude that the most likely scenario is a sudden and unrelenting decline in population due to food shortages and medical problems. The volume of industrial production will be halved due to the depletion of environmental resources. Such a situation will arise within the year 2100. A possible alternative is related to the stabilization of capital growth (that is, capital investment must equal depreciation) and population and, on this basis, ensuring a state of dynamic "global equilibrium" both in each region and in the world as a whole. We draw your attention to the fact that this positive forecast is possible only if all methods of improving the situation are applied in parallel, on a global scale and start no later than 1975. With all other components, the predicted model of the Club of Rome gives negative consequences, say, a global food shortage will be felt even before 2100. Since 1972, new components, such as the global greenhouse effect, etc., have been added to the list of environmental threats.

Thus, in the present day, the prediction of the social consequences of human, primarily technical, activity takes on the character of a new global problem "society is a disaster". Since humanity within the noosphere has acquired global status and entered an era of irreversible development, the majority of various types of cataclysms are global in nature. The current situation is already such that even their complete solution (which is almost impossible) will not bring civilization out of the impasse, but will only give rise to new global problems. But humanity is looking for a way out. In particular, a relatively independent direction of modern Western philosophy - futurology or "the science of the future" - was created. Within this direction, the search for substantiation of future social realities, modeling of the dynamics of the development of global problems is carried out, social forecasting is carried out, which gives an understanding of the (probability) historical perspective. Theoretical modeling and psychological anxiety of society is already supplemented by real practical actions. But in general, even today, the question remains open, the search continues, and the situation worsens.

Philosophers and scientists are currently offering various options for getting out of the global environmental crisis, which is inexorably approaching. Optimistic, but somewhat fanciful, can be considered reflections that modern civilization has already reached a level of development in which the growth of production in almost all branches of the economy can be carried out in the conditions of a progressive economy without the involvement of additional natural resources and energy. Humanity can be twice as rich in the future, using only half the resources. From another point of view, all the problems faced by modern humanity can be solved only through the development of technology, but smarter, more meaningful, more humanized, and so on.

But the main thing is that by now almost everyone has understood that:

• it gives a different understanding of the solution of applied problems, because each of them must be considered in the space of these complex dimensions.

• the planet is not only nature, it is a complex noospheric system, in relation to which we cannot act in a traditional engineering manner, according to a narrow engineering logic, that is, as infinite sources of energy and natural materials;

• effective democratic mechanisms for assessment, prohibition, etc., i.e. permanent environmental monitoring and control of the situation, must be formed. The question is how to achieve this.

Such ideas allow us to look at technology not only as a complex structural and morphological formation, but also allow us to connect research on the methodology of engineering activity, with the methodology of project activity, scientific ideas, allow us to connect a plan related to the study of technology, and axiological ideas, and the pictures we use. It turns out that today technology develops within the framework of certain pictures: pictures of nature, pictures of engineering activity that draws from nature, pictures of needs that technology provides. And all these paintings are permeated by the presentation of technology as the realities of nature, culture, and activity. That is, these are not just engineering tasks, but tasks related to the existence of global cultural formations, organizational systems, and value attitudes. Therefore, the modern philosophy of technology faces the task of exploring more deeply and fully the essence and structure of technical knowledge, its place in the noosphere and prospects for development in the general cultural context.

All this is the circle of problems that is investigated in the philosophy of technology.

## 5.3. Questions for self-testing of knowledge

1. Define the term technosphere. What elements are used to highlight in it structure?
2. How do technical sciences differ from natural sciences?
6. Why the concept of technological determinism is a product of thought 20th century?
3. What determines the specificity of the cognitive activity carried out in process of creating technological objects?
4. How is the formation of a technical theory?
5. What functions in technical theory do mathematical theories perform?
6. What are the main tasks facing the philosophy of technology?

## Tasks for independent work

The independent work of a master's student from the course "Philosophical problems of scientific knowledge" has two components:

1. Preparation and writing of a creative work.
2. Independent processing of course topics.

### 1. Themes of creative works

1. Categories of symmetry and asymmetry in philosophy and mathematics
2. Narrative in philosophy and science
3. Text and context in determining the meaning of a word
4. Hermeneutics and the process of understanding the text
5. Interpretation of the category of time in philosophy and physics
6. Hypothesis based on the example of physical knowledge
7. Philosophical foundations and components of human creative activity
8. Style of scientific thinking
9. Philosophical concept of the paradigm of T. Kuhn
10. The problem of creative approach in technical sciences
11. The essence of the system-structural approach as a methodological principle
12. Fundamentals of quantum physics in a philosophical context
13. Philosophical context of quantum entanglement
14. Truth, truth, post-truth, interpretation
15. "Demonism of science" and environmental problems in modern society
16. Relationship between philosophy and mathematics
17. The problem of the existence of mathematical objects
18. The problem of the truth of mathematical knowledge
19. Fundamental and applied research in technical sciences
20. The civilizational concept of O. Spengler and A. J. Toynbee: a non-classical paradigm of social development

21. Correlation of language and thought units in technical sciences
22. Linguistic features of scientific and technical style
23. Philosophical problems of the theory of space and time
24. Physical laws and causality
25. Hermeutics as a methodological principle. Hermetic approach
26. The problem of determinism in modern physics
27. Relationship between hermeutics and interpretation
28. Modeling method in cybernetic systems
29. Categories of symmetry and asymmetry in philosophy and mathematics
30. Interaction of everyday and scientific language
31. Philosophical foundations of cosmological models
32. Philosophical meaning of the concept of "paradigm"
33. Mathematical modeling as a philosophical problem
34. The problem of the relationship between epistemology and epistemology
35. Methodological and philosophical aspect in the study of human thinking, cognition and communication
36. Scientific creativity as a philosophical and educational problem
37. Modeling method as a cognitive tool in applied mathematics
38. The role of imagination in philosophy and science
39. The concept of matter in philosophy and modern science
40. Computer modeling as a cognitive tool
41. Ethics of a scientist
42. System-structural and comparative research principles
43. The relationship between empirical and theoretical methods of knowledge in modern physics
44. Relationship between interdisciplinary and scientific methods of cognition
45. Information and its reflection in philosophy and science

**2. Independent processing of course topics**

**Topic: Western and domestic paradigms of the philosophy of science**.

1. Methodological traditions of empiricism and rationalism in Western philosophy (Fr. Bacon, R. Descartes, O. Comte, E. Mach, E. Husserl).

2. Philosophy of science of the analytical school (B. Russell, L. Wittgenstein, M. Shlik, etc.).

3. Critical rationalism of K. Popper. Pluralism of methods (P. Feyerabend).

4. Peculiarities of domestic scientific methodology (V.I. Vernadskyi, B.M. Kedrov, O.L. Nikiforov, G.I. Ruzavin, V.S. Stepin, G.P. Shchedrovytskyi, B.G. Yudin, etc. .)

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## Topic: Peculiarities of scientific knowledge

1. The main forms of mastering the world: spiritual-theoretical, spiritual-practical and subject-practical.

2. The concept of an ideal object in science. The problem of truth in philosophy and science.

**Literature:**

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**Topic: Traditions and innovations in the process of empirical and theoretical research**

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**Topic: Methodological foundations of the study of spiritual culture and science.**

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**Topic: Subject and meaning of logic. Logic is formal and dialectical**

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2. Zherebkin V. E. Logic. - Kharkiv: Osnova, 1995. - 256 p.

3. Konverskyi A. There is Logic: Textbook. - K.: The Fourth Wave, 1998. - 272 p.

4. Khomenko I. V., Aleksyuk I. A. Fundamentals of logic. - K.: Golden Gate, 1996. - 256 p.

**Topic: Basic laws of logic. Concept, judgment, inference.**

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## GLOSSARY

**Axiology** (from the Greek - value) is a branch of philosophy that investigates the nature of values, their types, relationships, dynamics in a socio-historical context, and their role in a person's life.

**Aposteriorical** (from Latin - "after experience", "on the basis of experience". The term is used to characterize human knowledge as it appears through experience.

A priori (from Latin - "without previous experience", "originally", or "before experience"). The term refers to views on the source of knowledge and the process of cognition. Proponents of apriorism believed that a person has innate (pre-experienced) basic ideas, from which knowledge is developed through deduction.

**Being** is the starting category of philosophy, which asserts that the world, a set of things and processes, is present, existent. Through the category of "being", the fact of the existence of certain objects and phenomena is emphasized.

**Relationships** are a way of interdependent existence of objects of a certain identity, the essence of which is that they have a real opportunity with the need to enter into an actual connection and interaction under appropriate conditions through the mediation of mechanical, physico-chemical and other processes.

**Hypothesis** (from the Greek - assumption) is a certain probabilistic assumption about a significant connection between phenomena.

**Epistemology** (from Greek - knowledge - λόγος - teaching) is a branch of philosophy that investigates the cognitive relationship of man to the world, the conditions, types and forms of knowledge, the problem of truth.

**Deduction** is a method of transition from general to partial propositions, or in other words, deriving new truths from already known truths according to the rules of logic.

**Activity** is qualitatively different from the processes in living and non-living nature, a way of interaction of people with the environment, which is characterized by purposefulness, mediation by artificially produced tools, compatibility, and others.

**Dogmatism** (from Greek - thought, teaching) - a way of thinking with dogmas (invariable propositions). Dogmatism is characterized by uncriticalness towards dogmas, conservatism of thinking. In philosophy, dogmatism is expressed in accepting certain propositions as absolutely probable. Dogmatism is opposed by skepticism and criticism.

**Dualism** (lat. dualis - double) is a philosophical system in which two balanced but opposite principles are recognized, for example, in Descartes, these are bodily and spiritual substances.

**Spiritual** (mental) is a general name for phenomena of the human psyche, such as thoughts, feelings, emotions, etc., which are partially covered by the concept of consciousness.

**An experiment** is an active intervention of the subject in the processes of the external world for the purpose of knowledge, characterized by a purposeful impact on the object by its removal, isolation from random circumstances and those that hide its own nature.

**An ideal** is a concentrated expression of norms of perfection, a pattern of behavior and a targeted direction of life.

**Idealism** (fr. idéalisme, through Latin Idealis - idea) is a philosophical worldview, according to which the spiritual principle is the basis of existence. From an epistemological point of view, idealism believes that a person has a certain prior (beyond any experience) knowledge that clarifies, organizes, and brings his prior intuitions into the form of a logically consistent conceptual framework. An idealist is inclined to think that the principles of science and philosophy can be substantiated without going beyond one's own (or universal) consciousness. The term has been in use since the 18th century.

**Induction** is the transition from knowledge of individual facts to general knowledge, when conclusions about the general properties of objects of a certain class are made on the basis of the study of individual facts.

**Truth** is the correspondence of thoughts to reality.

**History** - in the most direct sense of the word means the presence of social reality in time.

**Category -** in philosophy, it is customary to call the most general concepts categories (from the Greek - statement, sign, definition, judgment).

**Conceptualism** is a philosophical position during the Middle Ages that recognized the presence of general concepts (concepts) in the human mind as a special form of knowledge of reality.

A concept is a certain way of understanding a phenomenon, or a leading idea.

**Creationism** (from Latin - creation, generation) is a theological concept according to which the whole world, in all its forms, was created by God.

**Culture** is a social program of activities and a set of values, ideas about the world and rules of behavior common to large groups of people.

**Logos** (Greek) is a multi-meaning term introduced into philosophy by ancient Greek thinkers. Meant "word", "language", "thought", "reason", "law".

**A person** is a creature distinguished by the presence of culture, which is not inherited genetically, but transmitted and developed through language, learning and imitation on the basis of transforming activity. A person can also be represented as a social-cultural form of existence of a biological being of the species Homosapiens.

**Materialism** (from the Latin materialis - material, objective) is a philosophical worldview according to which matter (objective reality) is ontologically the first principle relative to the spiritual, which is derived from the material. From this it follows that nature and humanity do not agree with principles, but on the contrary, principles are true only insofar as they correspond to nature and history.

**Matter** is a concept that covers everything that exists objectively, that is, outside the consciousness of people.

**Metaphysics** (from the Greek - that which is after physics) is a section of philosophy that elucidates the fundamentals and principles of being. Since ancient times, metaphysics has been understood as the philosophical teaching about the first principles and causes of all things. A critical attitude to traditional metaphysics was initiated in the 18th century. D. Hume and I. Kant. Later, Hegel gave this term the meaning of anti-dialectical thinking. During the XIX-XX centuries. there were attempts both to refute any metaphysics and to give updated versions of it. Nowadays, we can say that it is not metaphysics that is being devalued, but changes in its paradigms are taking place, and that is why three forms of metaphysics are distinguished in the history of metaphysics: ontological metaphysics, transcendental philosophy of consciousness, and transcendental semiotics.

**Method** (Greek) – a method of action, a set of measures for achieving a certain goal, solving problems or tasks.

**Methodology** is the science of methods of cognition as a special section of epistemology; in another sense, the term expresses a plurality of methods.

A model (from the French - a sample) is a system that exists in reality or in thought, which, reproducing the object of research, is able to replace it in such a way that its study gives the researcher new information about this object.

**Modeling** is the construction of a model and its subsequent research by thought or by means of a real experiment.

**Monism** (Greek - unit) is a philosophical system in which all varieties of being are ultimately reduced to a single principle.

**Science** is systematized, developing theoretical knowledge; as well as a certain type of intellectual activity aimed at acquiring such knowledge that can become the theoretical basis of any other human activity.

**The scientific picture of the world** is a complete system of specifically scientific knowledge about the universe or its individual parts and sections (in this case, we talk about the physical, biological, geographical, etc. picture of the world).

**Nominalism** (lat. nomina - name) is a philosophical position in the Middle Ages that denied the real existence of the universal, asserting that the universal exists only as a name after things.

The noosphere is a concept that contains the idea of the need for a rational organization of the relationship between society and nature on the part of the united humanity.

**Ontology** (lat. - being, that which exists - λόγος - teaching, science) is a section of philosophy that solves the most general questions of existence, such as its forms, structure, properties, space, time, movement, etc.

**Description** is a system of recording data from observations or experiments using notations accepted in science.

**Pluralism** (from the Latin pluralis - numerous) is a philosophical system according to which there are several or many independent principles of existence.

**Nature** - in philosophy, the concept of nature is used in several meanings. Broadly speaking, nature is the same as matter. This sense of nature encompasses society as well. In a narrower sense, nature is the immediate objective environment in which human history unfolds, something that man encounters all the time. Additional meaning of the concept of "nature" is seen in the case of emphasizing the essence of something (for example, "human nature").

**Natural environment** is that part of nature that surrounds people and affects them, and which they themselves influence through their production activities. By the second half of the 20th century. the term geographical environment was used in the sense of a part of nature, namely the geographical envelope of the Earth, in which the historical process unfolds. Nowadays, the term "natural environment" has become common, since the geographical envelope, as shown by technical progress, no longer limits the spatial boundaries of human activity.

**A problem** - in relation to science, means a contradiction between new facts and the explanatory possibilities of an old theory.

**Space** is a way of coexistence of objects when they are coordinated next to each other, located next to each other.

**Reality** (from Latin - valid) is a philosophical position during the Middle Ages, which attributed real existence only to general concepts, universals.

Reality is a concept that emphasizes existing being, being actual, actual, as opposed to say, being potential or already lost.

**Consciousness** - in a broad sense, this concept expresses all mental processes characteristic of a person, and therefore it can be stated that the spiritual is carried out in a person as consciousness. In a narrower sense, consciousness means only the highest form of a person's spiritual understanding of himself and the world around him, that is, mind and thinking.

**World** is a totality of reality revealed to people.

**Worldview** - a system of extremely general views of a person on the world and his place in it, on the attitude of a person to the reality that surrounds him, and to himself; these are the most generalized views on the meaning of life and the goals of human activity. A system is an object characterized by integrity, organization, the presence of information flows and connections that create integrity.

**Sophism** (Greek – trick, trick) is a false inference made in such a way that at first glance it appears to be correct. In ancient Greek philosophy, sophisms were used to win debates at any cost.

**Sophists** are those ancient Greek philosophers ("teachers of wisdom") who considered knowledge to be relative, denied the objectivity of truth, and used sophistry.

**Observation** is a purposeful perception of the object of scientific research, which is carried out directly or with the help of devices.

**Structure** - (from Latin - building; arrangement, order) a set of established connections of an object that ensure its design as a given, identical to itself.

**Society** is a systemic unity of the social results of people's activities.

**Theory** (from the Greek - contemplation) is reliable, true knowledge that exists as a certain system of logically connected statements about the essential connections of certain aspects of reality.

**Tradition** is a mechanism of reproduction of social institutions and norms, in which their support is legitimized by one fact of existence in the past.

**Transcendental** - in Kantian philosophy, this term is used in the sense of characterizing the conditions of possible experience, thanks to which (conditions) the transition to knowledge takes place (from the Latin - to make a transition).

**Transcendent** - in Kantian philosophy, this term refers to a judgment about such an object that never occurs and cannot occur in human experience, eg, God, the world as a whole, etc.

**Universals** - general concepts, general ideas. The nature of universals became the subject of long debates in medieval philosophy.

**A fact** is an event, phenomenon, process that has entered the sphere of scientific knowledge and is recorded by observation or experiment.

**Philosophy** is a systematic reflection on the surrounding world and man, based on the critical power of the individual mind.

**Civilization** is a side of culture, the entire material world created by people (artifacts) as carriers of knowledge, skills and abilities that make it possible to adapt external phenomena and processes to meet material needs.

**Value** is a concept that is used: a) to indicate the presence of a corresponding quality in something; this meaning is felt in the characterization of objects and phenomena as those that "have value", "are valuable"; b) to denote those components of spirituality that reflect the specific attitude of people to natural, social and spiritual phenomena from the point of view of their significance.

**Time** is a way of changing the states of objects, when this change takes place sequentially, one after the other.

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