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On the Question of Scientific-Historical and Inter-Subject Relations of Physics and Mathematics in The Process of Their Teaching

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Abstract: This article provides information on the importance of teaching physics in close connection with mathematics in the preparation of future teachers in higher education institutions. Also mentioned is a brief history of the relationship between physics and mathematics, the role of mathematics in teaching physics, an important form of connection between physics and mathematics, and the importance of solving mathematical problems of physical content.

Keywords: Interdisciplinary communication, physical meaning, theory and experiment, mathematics, universality of Newton's research, Schrödinger's equations, special theory of relativity, object, matrix, space, equations of motion, history of physics.

Introduction: At present, there is probably no need to prove the importance of interdisciplinary connections in the teaching process. They contribute to the better formation of individual concepts within individual subjects, groups and systems, the so-called interdisciplinary concepts, that is, those whose full understanding cannot be given to students in a lesson of any one discipline (concepts of the structure of matter, various processes, types of energy).

The modern stage of development of science is characterized by the interpenetration of sciences into each other, and especially the penetration of mathematics and physics into other branches of knowledge. The connection between academic subjects is, first of all, a reflection of the objectively existing connection between individual sciences and the connection of sciences with technology, with the practical activities of people.

The development of mathematics from ancient times and physics to the present day has been the scientific and methodological basis in the development of natural and technical sciences (applied), in particular physics and integrative connections with other sciences (subjects).

Implementation of interdisciplinary connections helps students to form a holistic understanding of the phenomena of the surrounding reality and the relationship between them. Therefore, they make knowledge more practically significant and applicable in the future profession, develop and increase interest in the chosen profession. They help students to apply the knowledge and skills that they have acquired while studying some subjects, to use them when studying other subjects, and give the opportunity to apply them in specific situations [9].

Naturally, physical science includes: theoretical and experimental parts. Physics is a fundamental science, since it includes both theoretical and experimental studies of material systems, and is the basis for other natural sciences. Physics is an experimental science. An experiment confirms or denies the conclusions of physics, includes systematic observations, experiments and measurements. The theoretical part provides for generalizations, classification and analysis of experimental data, the establishment of physical laws, the advancement of scientific hypotheses and the creation of scientific theories. Mathematics, too, as a theoretical science, includes an applied aspect. In the historical development of science, mathematics as the basis of fundamental sciences forms abstract symbolic and digital types, their relationships and a system of rules for interaction between symbolic concepts, their quantities in accordance with the internal logic of the development of the subject of science. It is this approach and connection in the perception and mastering of the science of mathematics that is the foundation of the evolutionary development of natural sciences, in particular reflecting the internal logic of the development of objects and phenomena according to the laws of nature. Mathematics as a fundamental science evolved, objectively, in certain stages during its formation and development as part of the natural philosophy of antiquity. The first, initial formation of ancient mathematics was closely connected with the measuring and computational issues of practice during the formation of human civilization. Its further development led to the abstraction and reflection of objective reality in the forming and developing consciousness of ancient man - mental representations in the form of symbolic-sign models, systems and their relationships with the original - an object or phenomenon, in particular physical.

METHODOLOGY

In line with the above, it is clear that mathematics is a product of abstract, mental activity of the human mind. Therefore, the emergence of many areas of this science is (a product) essentially abstract. The applied aspect of their use is due to the search for solutions to various types of equations - practical, mathematical problems. Namely, such problems of mathematics in the study of objects and phenomena of objective reality are one of the applied aspects of its effective use in natural, in particular physical science.

Rational use of intra- and interdisciplinary connections and their relationships ensure the effectiveness of the mathematical apparatus in research of natural sciences, in particular physics. Another aspect of this effectiveness is the scientific - logical reflection (display) of qualitative and quantitative connections with reality in the language of mathematics.

In the context of our study, some historical and methodological aspects and stages of the development of physics are analyzed.

In the XIX-XX centuries, after the recognition of mechanics as a classical science, which is the main foundation for the formation of physics and physical theories.

It is necessary to note a certain historical and meteorological orientation of the formation and development of physical theories. In further development, they received a generalized theoretical and strict mathematical formulation. Thus, Kepler, based on astronomical and mathematical data (Tycho Brahe), rejected the theory of a circular planetary orbit. Having excluded the centuries-old - Aristotelian assertion that everything in nature is perfect, and a circle is a perfect geometric figure and the planets move in circles. Another mistake is the incorrect idea of the supporters of the Aristotelian doctrine that everything around (the Earth), i.e. reality is changeable, and the Earth at rest is motionless.

To substantiate Kepler's conclusions, in the form of physical laws, not only Newton's mechanics played a major scientific role, but also his mathematical contribution to the new direction of creating the theory of differential and integral calculus. Newton and his theory of gravitation, which proclaimed the universal law of nature - the law of universal gravitation. The influence of Newton's views on the development of physics. Analytical geometry according to Newton and the theory of motion of celestial bodies.

The universality of Newton's research is unique.

It should be emphasized that the history and methodology of the development of science, in particular physics, did not always require strict mathematical justification when creating and developing fundamental theories.

However, the disclosure of ideas and the content of physical connections (various) objects and phenomena was carried out by various logical and mathematical methods, as well as signs, symbols and their relationships in the interpretation of various solutions.

Thus, Maxwell used a system of partial differential equations to generalize the results of numerous experiments by Faraday and his predecessors.

It is appropriate to note that A. Einstein, when creating the special theory of relativity based on the generalization of Newtonian mechanics and various approaches to the theory of relativity, did not use a special, new mathematical apparatus. However, the methodological approach to physical phenomena was carried out on the basis of the relations between energy, mass, speed (of light), space and time formulated by Einstein. At the same time, many physicists, especially experimenters, in an attempt to reject Einstein's theory of relativity by experimental tests, on the contrary, led to its correctness [1]. As a result, the term "ether" turned out to be inadequate in relation to space.

According to modern concepts, space is a physical vacuum.

It should be noted that the harmonious structure of the presentation of the special theory of relativity, completed by Einstein-Minkowski, is based on multidimensional geometry (topology) [2]. Thus, the fundamental change in the approach to the relationship between space and time according to Euclid - Newton was the creation of the general theory of relativity by Einstein, which finally changed the world of Newtonian mechanics. Within the framework of the general theory of relativity, which united the inertial and non-inertial systems, the methodological relationship is revealed based on the special theory of relativity and the principle of equivalence, for this Einstein chose Riemannian spaces, studied by mathematicians long before the creation of the general theory of relativity [2].

At the end of the 19th century, difficulties arose in physically explaining the spectrum of thermal radiation within the framework of classical physical theories (Maxwell and others) [4]. This problem was solved by Max Planck, in contradiction with Maxwell's theory - classical electrodynamics, with thermal radiation, energy is emitted not continuously (discretely), but in separate portions - quanta. In this case, the energy of each portion is directly proportional to the frequency of the radiation and is determined by the formula [4].

The proportionality coefficient was called Planck's constant, and it is equal to: h = 6.63 10-34 J·s. After Planck's discovery, the most modern and profound physical theory - quantum physics - began to develop. Quantum physics is a section of theoretical physics that studies quantum-mechanical and quantum-field systems and the laws of their motion. The behavior of all microparticles is subject to quantum laws. But the quantum properties of matter were first discovered in the study of the emission and absorption of light.

DISCUSSION

The attitude of scientists of that time to the proposal of Max Planck was ambiguous. Such an attitude was conditioned by the established ideas about the continuity of natural processes and their main dynamic parameters of the categories: energy, momentum and angular momentum.

Another contradiction was the use of the generalization of the quantum hypothesis to explain the structure of levels. Niels Bohr's postulate that an electron moving along a closed trajectory does not radiate (energy) was in contradiction with Maxwell's theory [4]. Since, the Bohr model of the atom explains a large set of data on atomic spectra [3].

The Bohr model of the atom (the Bohr model, the Bohr-Rutherford model) is a semi-classical model of the atom proposed by Niels Bohr in 1913. He took as a basis the planetary model of the atom put forward by Ernest Rutherford. However, from the point of view of classical electrodynamics, an electron in Rutherford's model, moving around the nucleus, should emit energy continuously and very quickly and, having lost it, fall onto the nucleus. To overcome this problem, Bohr introduced an assumption, the essence of which is that electrons in an atom can move only along certain (stationary) orbits, being on which they do not emit energy, and radiation or absorption occurs only at the moment of transition from one orbit to another. Moreover, only those orbits are stationary, when moving along which the angular momentum (angular momentum) of the electron is equal to an integer number of Planck's constants

As a result of this approach to the problem according to Planck, it became possible to reconcile the contradictions between Maxwell's theory and Bohr's model.

It should be noted that M. Planck and N. Bohr did not need to develop new methods of calculation in mathematics for quantitative integration of radiation spectra.

However, to implement quantum, a solid foundation was needed, in line with the elimination of the above contradiction. Such a foundation was the Schrödinger equation. When deriving the famous equation, Schrödinger relied on the mathematical theory of magnetic operators. At the same time, it became possible to introduce a general equation of motion, which at $h \to 0$, in the limit, passed into Newtonian mechanics, where each value is specific and understandable.

In the Schrödinger equation, there is little content about the wave function. What is its physical meaning? It should be noted that the physical meaning of the function, initially, was not clear even to Schrödinger himself [4]. Nevertheless, the wave formalism of Schrödinger's theory was accepted, since it made it possible to solve problems of quantum mechanics using well-developed methods of mathematical physics [5]. In 1926, the generally accepted idea of the physical meaning of the wave function was accepted by the hypothesis of the theoretical physicist Born, according to which the square of the modulus of the wave function determines the probability of detecting a particle at a given point in space, i.e. the function received a probable interpretation [4]. At the same time, (1926) W. Heisenberg proposed a matrix form of the equation of quantum mechanics. As Niels Bohr notes [7], although Heisenberg was not familiar with the basics of matrix calculus and he proposed rules for operations with matrices.

CONCLUSION

The implementation of the idea of interdisciplinary connections in pedagogy and teaching methods is closely connected with the methodological views of teachers on the problem of synthesis and analysis of scientific knowledge as a specific expression of differentiation of sciences. The theoretical and practical solution to this problem changed in accordance with the development of society, its social orders of pedagogical science. The approval and strengthening of the subject system of teaching in the modern educational process is inextricably linked with the development of the idea of interdisciplinary connections [9].

From a brief analysis of the scientific, historical and methodological foundations of the relationship between physics and mathematics, the following conclusions follow:

1. The scientific discovery of physical laws and patterns is based on the corresponding theoretical mathematical apparatus of relationships, expressions and theories in the form of a system of equations.

2. Physical theories, laws, various mathematical methods and their relationships are interconnected and interdependent.

3. New physical theories have been developed (are being developed) by scientists (from different countries), independently and objectively.

4. To focus the attention of teachers and students on the key aspects of academic subjects that play an important role in revealing the leading ideas of sciences.

5. To form the cognitive interests of students by means of a wide variety of academic subjects in their organic unity;

6. To carry out creative cooperation between teachers and students;

7. To study the most important ideological problems and issues of our time by means of various subjects and sciences in connection with life.

REFERENCES

Alekseev I.S. Development of ideas about the structure of the atom. Novosibirsk, Publishing House "Nauka", 1968

Buravikhin V.A., Egorov V.A. Biography of the electron, Moscow Publishing House "Znanie" 1885

Kudryavtsev P.S., Course in the history of physics. Textbook. M.P., 1982, 448 p.

Nevanlinna R. Space, time and relativity. Moscow Publishing House "Mir", 1966

Nikolaev P.N., History and methodology of physics, Volumes 1 and 2, Moscow State University, 2014

Planck M. On Schrödinger's works on wave mechanics. Moscow Publishing House "Nauka", 1975

Sitruchkov V.V., Yavorsky B.M. Issues of modern physics. M. Education, 1973

Smirnova M.A. Theoretical foundations of interdisciplinary connections - M., 2006.

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