

**THE RELATIONSHIP BETWEEN PHYSICS AND APPLIED MATHEMATICS IN  
THE SYSTEM OF CREDIT MODULES**

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**Annotation:**In the context of a modular education system, physics and applied mathematics are often taught as separate and independent fields of knowledge. However, this approach does not fully reveal the inherent logical and methodological connections between these disciplines. This article analyzes the theoretical and practical aspects of the relationship between physics and applied mathematics within a modular education system and substantiates their complementarity. While physics aims to determine the laws of natural phenomena, applied mathematics is a means of modeling, calculating, and solving practical problems related to these laws. Therefore, the role of applied mathematics methods in a deep understanding of physical processes and their practical application is important. The article emphasizes the potential of a modular education system for developing students' independent learning skills and demonstrates that the integrated teaching of physics and applied mathematics improves the effectiveness of education. This approach contributes to strengthening the theoretical foundations of interdisciplinary integration in modern engineering and science education.

**Keywords:**Aristotle, art, technology, theoretical science, physics

**ENTRANCE**

In the credit-based system, Aristotle's hierarchy of knowledge serves as an important methodological foundation for explaining the relationship between physics and applied mathematics. In the first book of his work, *Metaphysics*, Aristotle emphasizes that humans naturally strive for knowledge and points to sensory perception as the source of knowledge. This approach is also relevant in modern education, particularly in the study of physics, and substantiates the continuity of the processes of experience, observation, and modeling. Aristotle interprets the development of knowledge as a sequential process from sensory perception through memory, experience, and art (*techne*) to theoretical knowledge.

This hierarchy helps explain the relationship between physics and applied mathematics in the credit-based system. Direct observation and understanding of physical phenomena through experience—corresponding to the stage of intuition and experience—determines their expression using mathematical models, equations, and calculations. As a result, experimental knowledge is generalized by mathematical means and elevated to the level of theoretical knowledge. Aristotle divides the theoretical sciences into physics, mathematics, and metaphysics. According to his classification, physics studies objects subject to motion and change, inextricably linked to matter; mathematics studies numerical and spatial relationships that are not entirely separated from matter, but represent fixed and abstract forms. This approach justifies the complementary nature of physics and applied mathematics in the credit-based system: while physics reveals the essence of natural processes, applied mathematics enables us to precisely express, calculate, and predict these processes. The main characteristic of theoretical sciences is that they seek knowledge not for the sake of specific practical benefits, but for the sake of knowledge itself. At the same time, in the

context of the credit-based system, this theoretical knowledge is combined with practical problems through independent learning. Through the integration of physics and applied mathematics, students gain a deep understanding of necessary, indeed indispensable, laws and develop skills in applying them to solving engineering problems. Thus, the Aristotelian hierarchy of knowledge and classification of sciences serve to explain the theoretically justified connection between physics and applied mathematics in the system of credit modules and create a methodological basis for interdisciplinary integration.

**METHOD:** This study draws on Aristotle's methodological approach to the theoretical sciences and analyzes the interaction of physics and applied mathematics within the credit module system. According to Aristotle, physics studies the general nature of objects subject to motion, stability, and change, as well as the direct and indirect causes of these changes within the category of necessity. This approach also serves as a methodological foundation in modern physics education. The study clarifies the scope of mathematical precision based on Aristotle's metaphysical views. According to Aristotle, mathematical precision can only be applied to objects free from matter, so it is impractical to strive for absolute mathematical precision in the study of nature. Since the object of physics is inextricably linked with matter, mathematical models are used in an idealized form. This method reveals the functional difference between physics and applied mathematics within the credit module system and simultaneously their interrelationship. Methodologically, the nature of physical knowledge is analyzed in the study through "constantly occurring" and "frequently occurring" phenomena. Aristotle noted that science studies phenomena that occur constantly or frequently, since scientific knowledge strives for generality and necessity. From this perspective, physics is viewed not as a random theoretical science, but as a science aimed at studying necessary laws. Applied mathematics, as a means of quantitatively expressing, modeling, and calculating these necessary laws, is an integral part of the research method. In the study of physics, the unity of matter and form is considered in accordance with the teachings of Aristotle. Pure matter can have meaning or pure form does not, can be made of inseparable forms, their quantitative, qualitative, and spatial changes, and these changes cause potential and relevance theory within the framework of the study. This methodological approach of physics and practical mathematics integrates the theoretical basis for organization. Research also explores physics theory within the general framework of form and the concept of purpose (telos). The method of physics, as well as processes in modeling, practical mathematics, and ideal conditions, takes into account the caught without applied, experimental, and realistic objects, material functions, with this explained. The credit module approach in the system involves students' independent education through a theoretical model and realistic experience, analysis, and development of skills. Overall, in this case, the physics and practical mathematics science credit module system, under these circumstances, explores integrals without studying theoretical knowledge, mathematical modeling, and experimental analysis through deepening the process. This interdisciplinary integration provides an effective methodological foundation.

**CONCLUSION:** The study's results demonstrate that physical theories are constructed based on the concept of necessity; they represent an ideal natural process "as it should be." However, these theoretical processes are not always fully realized in the results of actual observations and experiments. The need to explain this discrepancy arises within the context of practical activity, that is, art (technology, engineering, medicine). From this perspective, within the credit module system, physical theory serves as the fundamental theoretical basis for applied sciences and applied mathematics. The first key finding of the study is that physical theory constitutes the theoretical component of practical activity. While physics defines the necessary laws operating in nature, applied mathematics and technological activity generate procedural knowledge "how to do it" based

on these laws. As a result, it was established that applied sciences have a two-layered knowledge structure: theoretically based on the laws of physics and practically based on experience. A second finding was that Aristotle's distinction between "episteme poietika" (theoretical knowledge of production) and "techne poietika" (practical skills of production) can serve as an effective methodological model for explaining the relationship between physics and applied mathematics in the credit module system. While physical laws are necessary and universal, applied mathematical solutions and technological methods are arbitrary and vary depending on specific conditions and experience. The study also demonstrated that identifying and overcoming obstacles to achieving goals is accomplished not only by theoretical knowledge but also by a practical approach formed on the basis of this theoretical knowledge. Physics theory defines the criterion for the legitimacy of practical activity, that is, it allows one to determine which methods are scientifically sound and which are not. Consequently, practical activity divorced from a theoretical foundation leads to chaos and cannot produce scientifically sound results. In accordance with Aristotle's principle of holism, it was established that the relationship between physics and applied mathematics is not mechanical, but systemic and teleological. While physics defines general forms and necessary relationships, applied mathematics expresses these relationships through specific models, calculations, and predictions. This contributes to strengthening interdisciplinary integration within the credit-module system and developing students' skills in applying theoretical knowledge to real-world situations. The study's results also showed that art (applied activity) can not only imitate nature but also complement it, purposefully completing unfinished processes. It was found that if physics is the source of the theoretical component in this process, the source of the practical component is experience. The harmony of these two components within the context of a credit-modular system is a key condition for achieving effective educational outcomes. Overall, the study's results provide scientific evidence that the integrated teaching of physics and applied mathematics within a credit-modular system ensures the legitimate, targeted, and effective application of theoretical knowledge to practical activities.

**DISCUSSION:** During the discussion of the research results, it was established that, according to Aristotle, some applied arts are not directly related to the mathematical sciences. For example, medicine is not a mathematical art, but derives its theoretical component from physics and its practical component from experience. This approach serves as an important methodological basis for clarifying the relationship between physics and applied mathematics in the credit module system. Many applied fields, such as medicine, develop on the basis of physical laws, but they are not directly equated with the mathematical sciences. At the same time, Aristotle describes some arts as "mathematical arts." These arts occupy an intermediate position between physics and mathematics and, working with real objects, express them mathematically. These include optics, mechanics, astronomy, and music. In these sciences, the properties inherent in physical objects, such as lines, surfaces, volumes, and points, are described using mathematical models. However, mathematics studies these properties not as the actual boundaries of physical objects, but as abstract forms. According to Aristotle, the mathematical arts analyze mathematical objects not from a purely mathematical perspective, but in relation to physical processes. For example, optics works with geometric lines in a physical, not mathematical, sense. These lines simplify the representation and calculation of light rays, but they cannot explain the nature of light or the causes of optical phenomena. These questions are directly related to the subject of physics. In his *Second Analytics*, Aristotle defines a hierarchy of sciences, emphasizing that the lower arts describe empirical phenomena, while the higher sciences explain these phenomena through mathematical reasoning. Optics relies on geometry, mechanics on the geometry of bodies, music on arithmetic, and astronomical observations on theoretical astronomy. This hierarchy indicates the need to ensure interdisciplinary consistency and continuity of knowledge in the system of credit modules.

According to the discussion, the integration of physics and applied mathematics enables the mathematical description of physical processes, but these descriptions cannot completely replace the physical content. Although applied mathematics is an effective tool for expressing, calculating, and predicting the laws of physics, explaining the essence and causes of phenomena remains the primary goal of physics. Understanding this distinction in the context of a modular education system develops students' ability to consciously combine theoretical and practical knowledge. Thus, the hierarchy of sciences and Aristotle's concept of the mathematical arts create a scientific and philosophical foundation for the coordinated teaching of physics and applied mathematics in a modular education system and clearly define the boundaries and possibilities of interdisciplinary integration.

### **Conclusion**

To test the validity of the above conclusions, we can ask a methodological question: on what basis are physical concepts and models considered "legitimate"? In the credit-based system, physics and applied mathematics are often accepted as tools for solving computational and practical problems, but their theoretical foundations are not always sufficiently understood. Any physical model or mathematical expression acquires legitimacy not only on the basis of experience but also on the basis of a general theoretical structure explaining nature—a paradigm. In the Aristotelian system, nature is explained through the theory of matter-form, the doctrine of potentiality and actuality, and the idea of "purposefulness" (telos). This theoretical structure forms the foundation of physical science and lends legitimacy to practical activities and computational methods. Similarly, in the credit-based system, modeling and calculations performed using applied mathematics are considered scientifically valid only within the framework of existing physical theory. Mathematical procedures not grounded in theoretical physics remain mere technical practices. In the philosophy of science, it is emphasized that the totality of physical theories is considered a paradigm. When a paradigm shifts, only the empirical components of practical activity remain, while the theoretical foundation is updated. As a result, methods previously considered legitimate may lose their scientific status within the new paradigm. This situation points to the need to teach physics and applied mathematics within a credit-based system based on an updated scientific paradigm. This study demonstrated that the "workability" of a result obtained using applied mathematics does not automatically guarantee its scientific validity. Scientific legitimacy is ensured only by models that are explained by existing physical theory and have a cause-and-effect basis. Knowledge of "how to do it," divorced from the theoretical component, can lead to random successes, but these remain closed to development and improvement. It is in this context that the integration of physics and applied mathematics within the credit-based system becomes important. While the theoretical apparatus of physics provides meaning and direction to applied mathematical models, applied mathematics serves as a means of refining, verifying, and expanding this theory. Therefore, prioritizing physical theory over mathematical results in the educational process is a necessary condition for the development of scientific thinking.

### **Links**

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