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Basics of Mathematical Field Theory in Relation to Geophysical Fields in Development of Systematic Nature of Applied Physical Reasoning

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Abstract

The relevance of the problem is conditioned by the need to change the extensive way of education development. It is impossible to increase the base of specific knowledge indefinitely. Today, something else is required: modern and intellectual education. The article is aimed at finding the way for an efficient combination of professional and fundamental education by establishing interdisciplinary relations of mathematics and physics with specialization disciplines. The current stage in the development of science is characterized by the interpenetration of sciences into each other, and especially by the penetration of mathematics and physics into other branches of knowledge. As a result, we proceed from the definition of physics as a science that studies the structure and properties of matter — substances and fields — and the forms of matter existence — space and time. This definition does not imply the reduction of all natural science to physics, but it means that the final theoretical bases of any field of natural science are of a physical nature. The materials of the article can be useful for professors of mathematics and physics in technical universities who need to know the content of specialization disciplines in order to understand what mathematical knowledge is particularly necessary for the specialists in certain branches of higher technical education.

MATERIALS AND METHODS

The leading method of this research is identification of system-forming concepts and formulation of the general principles of science, leading theories, and basic laws which are applied for the analysis of particular facts and individual phenomena. W. Thomson was the first to point out that vectors save chalk and expend the. Multilateral interdisciplinary relations help not only to teach students on a qualitatively new level, but also to lay the foundation for comprehensive vision and approach to solving complex problems of real life. In terms of differentiation and integration, the role of interdisciplinarity is contradictory. On the one hand, it deepens the differentiation, leads to the formation of new domains of research and even new disciplines at the intersection of disciplines. On the other hand, it is the leading factor in the integration of modern science (Bushkovskaya, 2010, p. 153). In summary, we can say that the practicability of the interdisciplinary approach is proved. This is confirmed by the “World Declaration on Higher Education for the Twenty First Century: Vision and Action” adopted by the participants at the World Conference on Higher Education in Paris in 1998 (UNESCO, 1998). The Declaration recommends to encourage interdisciplinary programs of the educational process and to teach future specialists using interdisciplinary approach to solving complex problems of nature and society.

RESULTS

The process of acquiring knowledge and professional skills is aimed at mastering the methods and means characteristic of the physical science. The proposed methodology for integrating mathematics and physics courses was tested in the control of students’ knowledge and proved its effectiveness (Vygodsky, 1966, p. 227). The introduction of this approach in the process of teaching mathematics and physics helps students to better understand the material.

Interdisciplinary integration in education broadens the horizons of future professionals and allows them to apply specialist knowledge in a wider range of fields. It is especially important in the modern world with its fast pace of technological progress that requires independence in searching for, analyzing and implementing knowledge. The course of mathematics, obligatory for most university programs, needs to be integrated into each specialization; it should offer tasks and problems relevant to each specific field of study. A good example of this approach is the application of mathematical field theory to the study of geophysical fields, theoretical and practical implications of which are discussed in the paper.

INTRODUCTION

Implementation of interdisciplinary integration in education is seen by us as one of the most promising educational trends. Why do we think so?

For now, the extensive way of educational development has substantially exhausted itself. One cannot endlessly enrich the store of specific knowledge. Today the requirements are different, modern and intellectual education is in demand. Within the walls of universities, students should become prepared for living in the high-tech competitive world. They are going to work in the world of modern technologies and devices, where the pace of change is very fast.

The interdisciplinary approach to education can be implemented by means of students' independent acquisition of knowledge from different disciplines; they can further apply this knowledge when solving their professional problems (Kosheleva, 2007, p. 35). However, in the framework of this particular paper we want to pay attention to the following. Studying physics ought to be interrelated with subspecialties and be based on examining the concise processes and phenomena relating to the professional activity of future specialists. The academic staff should clearly understand what kind of knowledge of physics specialists will require in their professional practice; for a successful study of geophysics, staff should be familiar with the modern geophysical methods applied for prospecting, exploration and development of oil and gas deposits.

Mathematics classes should provide specific examples when teaching mathematical methods applied in physics. This approach results in more understandable and persuasive instruction as specific examples and restrictions, arising from the very formulation of a physical problem, provide better understanding than cumbersome and numerous conditions and provisions, the necessity of which in abstract consideration is not obvious at all.

MATHEMATICS AND PHYSICS BASIS IN GEOPHYSICS STUDY

Geophysical methods of prospecting and exploration of mineral deposits are based on studying various natural (geomagnetic, gravitational, electromagnetic, geothermal, nuclear-physical fields, and elastic vibrations) and artificial physical fields (created by electric generators, explosions and explosive sources, and sources of ionizing radiation), changes in which are caused by the compositional and structural heterogeneity of the Earth's crust, as well as its variable properties and ongoing processes. Measurements of these fields' parameters are taken on, above, and underneath the Earth's surface. By geophysical fields, we mean physical fields formed by the planet Earth. Geophysical and physical fields differ only in their structural complexity that is caused by the compositional and structural heterogeneity of the Earth.

Geophysical fields include

1. Earth's thermal field;
2. gravitational field;
3. Earth's magnetic field;
4. Earth's electromagnetic field;
5. Earth's radiation field;
6. field of elastic or acoustic vibrations.

All these natural and artificial (man-made) geophysical fields are uncontrolled, i.e. they exist independently of the will of researchers who use them to solve certain problems related to the study of the Earth's crust, including environmental problems. There are widely used controlled fields, especially for geophysical studies of the Earth and prospecting and exploration of mineral resources, as well as for solving engineering, technical, and environmental problems.

Physical field is a form of matter that activates specific interactions among macroscopic bodies or particles comprising the matter. The concept of field is used in physics to indicate a set of values of a certain physical quantity given in each point of space or subspace. It originates from a material source and has two main features – intensity and potential. Intensity is the strength of a field at any point, a vector quantity that is determined by this strength, with which the field affects its source.(Gospodarikov A.P., 2017, p. 405). Field potential is a scalar, equal to the work done by external forces carrying a positively charged unit from infinity to the considered point in the field on condition that infinity strength equals zero.

Thus, using mathematical methods in various sciences has its specificity. The interdisciplinary content of the material systematizes and summarizes the knowledge in mathematics, physics and technical sciences. This problem–solution approach in education generates positive feedback and increases the cognitive interest and activity of students.

The concept of engineering education implies acquiring a vast knowledge in the field of natural sciences and mathematics, and it must be amplified by introducing examples of applied research in relation to specialization. At that, specialization means choosing priorities and giving illustrations of various applications of physics

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