European Journal of Humanities and Educational Advancements (EJHEA)
Available Online at: https://www.scholarzest.com
Vol. 7 No.05, May, 2026
ISSN: 2660-5589

SCIENTIFIC AND METHODOLOGICAL REQUIREMENTS FOR LEARNING THE BASIC CONCEPTS OF THE NANOELECTRONICS COURSE

Uzokova Gulnoza Saydullayevna
Karshi State University, Professor
e-mail:uzoqovagul@qmail.com
ORCID 0009-0002-0621-2859
Xoliqulova Saodat Yusuf qizi
Karshi State University, PhD student
e-mail: saodatxoliqulova93@gmail.com
ORCID 0009-0004-8043-8789
Tel: +998999570836

Article history:
Received: 7th April, 2026
Accepted: 6th May 2026

Abstract:
The article outlines the prospects for the science of nanoelectronics, the physical foundations of the laws studied in the course of nanoelectronics, scientific and methodological requirements for the study of the basic concepts of nanoelectronics**.**

The article shows the methods of developing practical skills in students and regular knowledge of the nanoelectronics course, as well as the use of research methods related to nanoelectronics.

The creative lesson model is justified, designed to develop creative thinking skills in the course of nanoelectronics,

Keywords: nanoelectronics, creative approaches, thinking ability, education model

INTRODUCTION. Nanotechnologies, considered modern technologies of the 21st century, have rapidly entered our lives and have become the most important priority direction of scientific development. In recent years, the development of science and technology has reached such an important milestone that the transition to it can radically change the living conditions of a person. This is due to the fact that nanotechnologies have begun to be applied to all areas of technical development. According to world-renowned experts, nanotechnology's manipulation of matter will bring about a major revolution in human life, with nanoelectronics in the future replacing silicon chips and increasing the overall performance of computers thousands of times. Cheap, lightweight, and durable nanomaterials will replace metals used in engineering and construction. With the help of nanotechnology, the automotive industry is developing environmentally friendly cars, in which highly efficient hydrogen fuel is used instead of gasoline in internal combustion engines. Solar cells based on nanomaterials, with a very high efficiency, are replacing fossil fuels in energy production. In short, nanotechnologies will have a significant impact on future economic sectors, human lifestyles, and social life.

The main goal of teaching nanoelectronics to undergraduate students is to familiarize them with fundamental knowledge of the principles of electronics at the nanoscale, the theoretical foundations of nanoelectronics, the mechanism of operation and applications of nanoscale devices, materials science, technologies, and practical devices, as well as to form a scientific worldview about the role of nanoelectronics in future technological progress.

ANALYSIS OF RELATED LITERATURE. The literature studied for the article includes scientific research works related to this topic. In particular, the textbook "Nanoelectronics" by E.N. Boresenko, "Nanotechnology in electronics" by V.N. Lozovsky and G.S. Konstantinova, "Physical foundations of micro and nanoelectronics" by Y.L. Parfenova and M.G. Khusainov, "Development of creative thinking in physics lessons" by N.V. Galichina and the textbook "Mechanisms for creating didactic support for teaching based on a creative approach" by M.M. Musurmonkulova, as well as the works of scientists who conducted research in the field of nanoelectronics in the republic and abroad, and sources from Internet sites served as the basis.

RESEARCH METHODOLOGY. Nanoelectronics is a science that studies the nanometer-scale networks of electronics. The educational goal of nanoelectronics is to familiarize students with the technology of obtaining small-scale structures and the basic laws of physical processes occurring in them, and the subject of nanoelectronics is small-scale structures (quantum dots, quantum wires (threads), quantum coils). To master this science, it is necessary to have sufficient knowledge and skills from the courses "General Physics" and "Quantum Physics" in the curriculum.

Teaching a nanoelectronics course requires a comprehensive approach that includes the use of modern methodological methods, innovative technologies, and a creative approach. In addition, nanoelectronics studies nanostructures and the physical phenomena that occur in them. The phenomena and processes that occur in nanostructures occur on the basis of certain laws. The study of the relationship between these phenomena and their laws is the main task of every science. As is known, classical physics mainly studies phenomena occurring in nature, including the interaction of bodies and the laws of their motion, phenomena associated with electromagnetic and light, the atom and its nucleus. However, various physical phenomena can also occur in nanoscale structures. It is currently difficult to indicate the exact boundaries of the science of physics in the study of such phenomena. Because each new discovery made and being made further expands the scope of application of physics. In studying the properties of nanostructures, the theory of zones, the quantum states of microparticles in micro and nanostructures, the reasons for the emergence of the idea of quantization in them, the atomic and molecular structure of nanostructures, and the processes occurring in them are covered.

In the process of studying nanoelectronics, the application of the principle of quantum dimensional effects, as well as quantum dimensional effects, the conditions for their manifestation, quasiparticles, the physical essence of potential wells and barriers, the migration and state of particles in them, dimensional quantization phenomena, quantized wells, quantized wires and dots, the use of semiconductor materials for superlattices, and the physical processes occurring in them are described.

In the process of studying the nanoelectronics course, the concepts of nanoparticles, nanoclusters, quantum dimensional effects, quantum dots, quantum wires, quantum wells, and the energy spectrum of electrons are systematically studied.

The behavior of electrons in nanoscale fields is determined by their reflection from the boundaries of such environments, the interference of electron waves, and the passage of waves through potential barriers. These phenomena explain quantum-scale effects in nanostructures, such as the quantization of the energy of electrons with spatial limitations in their movement, the passage of electrons through nanometer dielectric layers, the quantization of the resistance of nanowires, etc.

Nanoparticles are particles with a size of less than 100 nm. Nanoparticles consist of 10b or fewer atoms and their properties differ from the properties of a bulk substance consisting of the same atoms. Nanoparticles with a size of less than 10 nm are called nanoclusters. A nanocluster usually contains up to 1000 atoms. Many laws that are valid in macroscopic physics (macroscopic physics "works" with objects with sizes much larger than 100 nm) do not apply to nanoparticles. For example, certain formulas for connecting conductor resistances in parallel and in series do not work. Water in the nanopores of rocks does not freeze up to -20. . . -30 ° C, the melting point of gold nanoparticles is significantly lower than that of a bulk sample. The proportion of atoms on the surface increases with decreasing particle size. For nanoparticles, all atoms are practically "surface".. therefore, their chemical activity is very high. For this reason, metal nanoparticles tend to aggregate. At the same time, in living organisms (plants, bacteria, microscopic fungi), metals in most cases exist in the form of clusters consisting of a relatively small number of atoms.

In nanostructures, the motion of charge carriers is limited in at least one direction and forgets that they are Bloch charge carriers in that direction, that is, dimensional quantization occurs in that (selected) direction. In this direction, not only the momentum and energy spectrum of charge carriers are dimensionally quantized, but also their effective mass is dimensionally quantized. This leads to a sharp change in the energy spectrum of charge carriers and, in turn, to a sharp change in the nature of a number of physical phenomena in low-dimensional semiconductor structures. Due to the intelligent use of such physical processes, new lasers and discrete computers based on nanodots and nanoholes have also been born.

The size effect is understood as the dependence of the properties of an object on its size. This effect occurs when the size of the object in some direction is comparable to some critical size lk. In classical size effects, the classical size lk can be, for example, the free path of an electron, its diffusion length, etc.

Quantum size effects in electronic structures are observed when the role of the length lk is played by the de Broglie wavelength λ of electrons, which is a specific quantum size, i.e., when the size of the structure is of the order of λ in some direction. Quantum size effects are associated with the wave nature of electrons.

Quantum dot. A quantum dot is a zero-dimensional (1D) object. The motion of electrons is limited in all three directions. Nanocrystals on the surface of another material growing epitaxially are depicted in Figure 1.

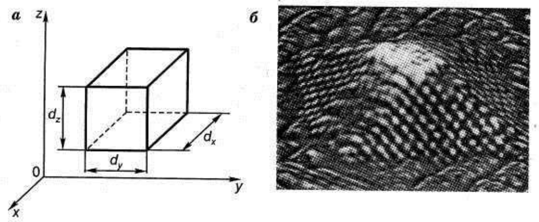


Figure 1

Quantum wire. A quantum wire (or string) is a one-dimensional (1D) object. The motion of electrons is confined along the y and z axes by cross-sections of dimensions dy and dz, respectively, and unrestricted along the x axis, respectively. The potential for free electrons in the wire is two-dimensional.

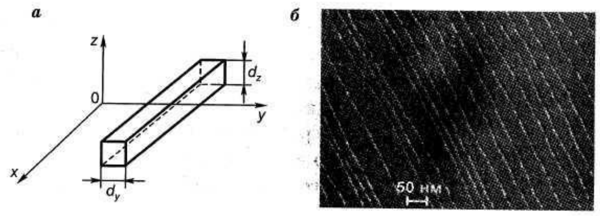
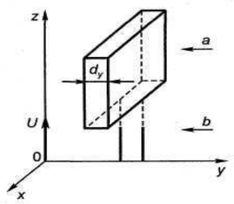


Figure 2

A quantum well is a two-dimensional (2D) object. It is a very thin layer of a crystal, the thickness of which is comparable to the de Broglie wavelength d, i.e. d∞λ. The system of electrons in such a layer is called a two-dimensional electron gas (or 2D gas).



The energy spectrum of electrons E and the density of quantum states gE are very important characteristics of objects that determine their electronic properties and response to external influences.

The energy spectrum is a set of possible values of the energy of a particle under given conditions. If the energy is quantized, the energy spectrum is called discrete (quantized), and if it can take on a continuous series of values, the spectrum is called continuous (continuous).

The density of states gE is the number of quantum states that correspond to a unit energy interval in a unit volume, surface or length, depending on the size of the object. Based on this definition, the density of states is determined as follows:

$$g(E) = \frac{dn(E)}{dE} (1)$$

where dnE is the number of possible states corresponding to the energy range from E to E dE. Knowing the density of states gE and the probability of their filling by electrons f E allows us to determine the distribution of electrons in quantum states in the system under consideration and to explain the electrical, optical and a number of other properties of the system. Since electrons have half-integer spin, their filling of quantum states is determined by the Fermi-Dirac distribution and obeys the Pauli exclusion principle.

ANALYSIS AND RESULTS. The process of teaching the course "Nanoelectronics" requires a systematic approach and the conscious use of modern methodological methods.

The scientific and methodological requirements for the formation of basic concepts in students for the course "Nanoelectronics" are as follows:

1. Justification of the relevance of the course:

- development of nanotechnology; nanoelectronics is one of the main directions of nanotechnology, which is important in terms of forming the necessary knowledge for the development of various fields (medicine, electronics, energy, materials).
- new opportunities and research: the study of nanoelectronics is new opportunities for scientific research and practical applications;
- training of specialists: the need to train specialists in this field for the development of nanotechnology and nanoelectronics;

2. Systematic presentation of the basic concepts of nanoelectronics:

- study of the basic concepts of nanoelectronics:
- introduction to the basic concepts and laws of nanoelectronics;
- training in considering physical processes at the nanoscale.
- understanding the principles of operation of nanoelectronic devices:.
- development of practical skills:
- study of the experimental foundations of nanoelectronics;
- use of modern equipment and research methods.
- Formation of scientific thinking skills: development of the ability to analyze, synthesize, think critically, and solve scientific problems.

3. Forms of training:

- lectures: theoretical presentation of the basic concepts and laws of nanoelectronics.
- seminars: active discussion of the topics being studied, problem solving, presentations of students' independent work.
- laboratory work: practical study of the basics of experimental work in nanoelectronics, use of modern equipment.
- project activities: development and implementation of research projects that stimulate creative thinking and in-depth study of the topic.

- Use of modern electronic educational resources, modeling: use of pedagogical software tools and computer models to visualize and study complex nanoscale phenomena.

4. Educational materials:

- textbooks and manuals: use of modern textbooks and manuals that provide information on the current progress and development trends in the field of nanoelectronics.
- scientific articles: introduce the latest achievements and modern views in the field, modern scientific articles to study in the educational process.
- online resources: use of creative lessons, interactive materials, online platforms to make lessons more convenient and interesting.

5. Assessment:

- test: use of tests to assess knowledge of the basic concepts and laws of nanoelectronics.
- project activities: stimulate students' creative approach to solving problems and developing projects.
- laboratory work: the level of mastery of practical skills, the ability to use modern equipment.
- oral presentation of results: assess the ability of students to clearly and systematically present research results.

6. Teacher's activities:

- high qualification: the teacher must have in-depth knowledge of nanoelectronics and modern educational problems.
- use of innovative technologies: the ability to use modern technologies to increase the effectiveness of education.
- stimulation of creative thinking: creating conditions for students to work independently, encouraging their creative approach to solving problems.

CONCLUSIONS AND SUGGESTIONS In conclusion, it can be said that pedagogical optimism, a person-oriented approach, has a strong impact not only on educational effectiveness, but also on personal development. Confidence in the student is manifested not only in his abilities, but also in his moral qualities. Pedagogical optimism is expressed in the process of problem-based learning, in the continuous improvement of cognitive (analytical thinking and theoretical approach aimed at improving the method of educational and research learning) tasks, in the development of students' educational and cognitive activities.

The formation of the basic concepts of the nanoelectronics course based on the above scientific and methodological requirements systematically develops students' abilities to acquire deep theoretical knowledge and practical skills in the field of nanoelectronics, to think creatively, to conduct independent research and conduct scientific research. The use of modern technologies and methods increases the efficiency of the educational process and creates an interesting, useful and effective educational environment for students.

REFERENCES:

1. Galichina N.V. Developing Creative Thinking in Physics Lessons. https://multiurok.ru/index.php/files/razvitie-kreativnogo-myshleniia-na-urokakh-fiziki.html.
2. Lozovsky V.N., Konstantinova G.S., Lozovsky S.V. Nanotechnology in Electronics. Textbook. – St. Petersburg. 2008. – 336 p.
3. Mikalko M. Hacking Creativity: How to See What Others Don't. – Moscow; 2001. P. 27.
4. Parfenova E.L., Tereteva L.A., Khusainov M.G. Physical Foundations of Micro- and Nanoelectronics. Textbook. – Moscow: Phoenix, 2012. – 240 p.
5. Umirzakov B.E., Normurodov M.T., Tashmuhammedova D.A., Tashatov A.K. Nanoepitaxial films and heterostructures based on silicon. Tashkent, 2012