

## **PHYSICS OF NEW TECHNOLOGIES**

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**Abstract:** This scientific article examines the development of new technologies in the 21st century that are based on physics – quantum technologies, nanotechnologies, physical systems integrated with artificial intelligence, bio-physics-based medical devices, plasma technology, high-temperature superconductors, and other innovative fields. The physical principles of each technology, their working mechanisms, role in industry, and applications in medicine, engineering, and ecology are discussed on a scientific basis. The main focus is on how the fundamental laws of physics contribute to the creation of innovative solutions in practice.

**Keywords:** physics, new technologies, nanotechnology, quantum technology, biophysics, artificial intelligence, plasma, superconductivity, medical technologies, physical innovations

### **Introduction**

Physics is the fundamental scientific foundation for the development of new technologies. From quantum mechanics to nanophysics, plasma technology, biotechnology, and AI-integrated systems, all advances rely on the laws of physics. Today, science and technology are developing at a rapid pace. Physics is the main scientific foundation that defines the essence of this development. It is precisely on the basis of physical laws that modern technologies, energy systems, computers, medical devices, space equipment, and other advanced systems are created. The “Physics of New Technologies” is not only a field of fundamental scientific approaches but also a discipline that embodies modern practical solutions. This article is devoted to analyzing the physical foundations of this technological revolution, providing a deep scientific-theoretical explanation of the newest technologies, and studying their areas of application and prospects. Physics participates in every stage of modern technological processes, creating solutions that radically transform human life. From quantum computers to nanomedicine, from AI-based physical devices to plasma-based energy sources, physics plays a leading role. The physics of new technologies has thus become an important scientific direction in building theoretical and practical foundations for these innovative areas. In this article, we systematically highlight these physical foundations and study technologies that serve science. In the development of modern technologies, the role of physical laws is invaluable. Every advanced device, software, or production process is essentially based on physical phenomena and principles. This section discusses the application of classical mechanics, quantum mechanics, electromagnetic field theory, thermodynamics, and relativity theory in modern technologies. Classical Newtonian mechanics plays a fundamental role in defining the motion of automated robots in industry. Manipulators, automated arms, and mechanical systems in production lines are designed based on the balance of forces and accelerations:

$$F=ma$$

This equation is the main basis for modeling motion in modern robotics algorithms. Especially for AI-assisted robots operating in changing environments, physics is essential. Electromagnetism: Mobile communication, the internet, and satellite-based transmission technologies are all based on Maxwell's equations. The propagation, interference, and reflection of electromagnetic waves are crucial in optimizing mobile network systems. Algorithms for digital signal transmission and coding are developed on the basis of physical laws. AI-based automatic frequency control technologies are advancing this field further. Thermodynamics: Modern power stations, solar panels, and hydropower plants rely on the first and second laws of thermodynamics in heat exchange and energy conversion processes:

$$\Delta Q = \Delta U + \Delta A$$

These laws help to increase energy conversion efficiency. At the nanoscale, entropy plays an important role. Controlling thermal disorder allows for the creation of nano-energy storage systems. Quantum mechanics: Unlike classical bits that store either 0 or 1, qubits exist in superposition, allowing high-capacity information storage. This principle underlies quantum computing. For example, quantum cryptography and real-time big data analysis rely on such properties. Quantum tunneling is vital in the operation of semiconductors and modern microprocessors. Relativity: Einstein's special and general relativity form the basis of modern GPS systems. As satellites move in Earth's orbit, time differences arise; without accounting for them, positioning errors of up to 10 meters would occur.

### **Nanotechnology**

Nanotechnology is the field of creating new materials and devices by controlling the properties of matter at the atomic and molecular level. It lies at the intersection of physics, chemistry, biology, and engineering. Physical theories play a central role in creating, managing, and applying nanostructures. Nanomaterials are materials with dimensions between 1 and 100 nanometers, where physical properties differ drastically from the macroscopic scale. At such small sizes, electron behavior follows quantum mechanics, resulting in:

Changed electrical conductivity

Altered magnetic properties

Strong optical interactions with light

For example, quantum dots can emit different colors of light depending on their size. Carbon nanotubes (CNTs) are cylindrical nanostructures of carbon atoms with:

Very high strength ( $\approx 100\times$  stronger than steel)

High electrical and thermal conductivity

Ballistic electron transport (near-collisionless movement)

Graphene, a single-atom-thick carbon layer, is a Nobel Prize-winning material. It played a key role in the study of the quantum Hall effect and two-dimensional electron gases. Metal nanoparticles interacting with light produce localized surface plasmon resonance (LSPR), which enables precise control of light. Applications include:

Optical chips

Quantum communication systems

Nano-scale lasers

Nano-electromechanical systems (NEMS): include nanoresonators, nanoactuators, and nanosensors for measuring temperature, pressure, and chemical composition with extreme accuracy. Biomedical nanotechnology: Nanocapsules and nanocoatings deliver drugs directly to diseased cells (diffusion and adsorption physics). Superparamagnetic nanoparticles enhance MRI imaging. Nanomaterials can destroy cancer cells through photodynamic therapy. Thus, nanotechnology physics, based on quantum mechanics, electromagnetism, thermodynamics, and nanoscale forces, brings physics closer to practice. Quantum Technologies. Quantum technologies rely on non-classical features of quantum mechanics: superposition, entanglement, tunneling, and interference. Superposition: A quantum system can exist in multiple states simultaneously – the foundation of quantum computing. Entanglement: Two particles remain correlated even when separated – crucial for quantum teleportation and secure communication. Tunneling: Enables quantum transistors and scanning tunneling microscopes (STM). Quantum computers: Use qubits; however, maintaining qubit stability requires cooling near absolute zero. Quantum cryptography: For example, the BB84 protocol uses photon polarization to transmit information securely. Quantum sensors: Measure magnetic fields, brain activity, or gravity with unprecedented precision. Atomic clocks: Provide the most accurate timekeeping (e.g., cesium clocks), ensuring GPS synchronization. Quantum technologies significantly increase computing speed, information security, and measurement accuracy, but technical challenges remain.

### **Artificial Intelligence (AI) in Physics**

AI imitates human intelligence and is widely applied in physics for modeling, theoretical calculations, experimental data analysis, and optimization. Neural networks solve nonlinear equations, predict outcomes, and analyze signals. Deep learning enables multi-layered structural modeling of physical processes. AI in climate physics: Models global changes (CO<sub>2</sub>, temperature, ice caps). AI in experiments: Autonomous robots conduct experiments, analyze results, and plan new studies. Medical physics: AI models tissue properties for biomaterial testing. AI accelerates problem-solving in physics, enabling more accurate predictions and innovative approaches, but

must be carefully aligned with physical laws and ethical principles.

### **Biophysical and Nanophysical Technologies**

The integration of biology, physics, and technology has created new approaches in healthcare, ecology, energy, and materials science. Optogenetics: Controlling genes with light (based on quantum optics and photoselectivity). Quantum dots: Semiconductor nanoparticles that absorb and emit photons. Magnetic nanoparticles: Used in MRI as contrast agents (superparamagnetism). Drug delivery: Nanoparticles transport medicine directly to target cells. These directions expand opportunities for human health, environmental protection, and energy efficiency. Physics provides the theoretical and experimental basis for these technologies.

### **Conclusion**

The physics of new technologies is a key pillar of modern science and industry, enabling the development of next-generation technologies based on fundamental physical principles. This field encompasses nanophysics, quantum technologies, AI, photonics, biophysics, materials science, and energy. Their integration drives the creation of innovative products. Research shows that new physical technologies are miniaturizing devices, improving energy efficiency, and accelerating information transfer and processing. Quantum computing, nanoelectronics, and robotics are expected to transform society in the near future. In medicine, ecology, and energy, new technologies protect health, optimize resources, and help solve global environmental challenges. In conclusion, the physics of new technologies is not only a scientific field but also a strategic direction of societal progress. Investing in it, training young specialists, and strengthening international cooperation will pave the way for innovative development. Studying and applying this field is crucial for building a sustainable, high-tech future for the next generations.

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