MODELLING OF PHYSICAL PHENOMENA AND DEVELOPMENT OF VIRTUAL LABORATORIES: APPLIED ASPECTS

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ANNOTATION

Virtual modeling tools allow the replication of physical processes in real-world conditions, providing the opportunity to study their laws in greater depth. Therefore, improving virtual laboratories and modeling methods is a relevant issue. The aim of this study is to investigate methods for modeling physical phenomena, analyze the applied aspects of virtual laboratories, and determine the effectiveness of their use in various fields. Experimental methods and data analysis techniques were used in the research process. Computer simulation methods were applied to model physical equipment. The software tool "Blender" was used for this purpose. As a result of the study, a number of important conclusions were made in the field of modeling physical phenomena and developing virtual laboratories. The use of modeling methods in studying physical processes was shown to help understand their complexity and describe them numerically. Furthermore, their effectiveness in real engineering, scientific, and industrial processes was determined.

Keywords: physical modeling, virtual laboratory, computer simulation, numerical modeling.

INTRODUCTION

Laboratory experiments play an important role in science and education. Due to the opportunities offered by information and communication technologies in the field of education, virtual laboratories have emerged as an alternative to traditional, experimental laboratories. In addition, the existence of virtual laboratories opens up new perspectives in ensuring the sustainability of higher education. They serve as an effective method of preparing students to understand scientific principles, as they allow scientific phenomena to be represented in automated and virtual practical activities through computer modeling [1].

Virtual laboratories are more efficient compared to physical laboratories, especially when they provide interactive opportunities for students and researchers to understand complex phenomena. Lynn De Jong and Zacharia study the role of physical and virtual laboratories in science and engineering in their works. The research results showed that physical laboratories often require specialized equipment and space, while virtual laboratories offer the possibility of saving resources [2].

The mathematical pendulum is one of the important physical models in classical mechanics. It is often used to determine the acceleration due to gravity. Traditional methods of measuring gravitational acceleration through the period of

the pendulum may lead to errors, while virtual laboratories help improve the accuracy of these calculations.

Hoo and other scientists in their studies consider the fuzzy control of a single pendulum system with two contours of inverted systems and virtual reality simulation. In this study, the dynamics of the inverted pendulum were modeled using virtual reality (VR) simulation. The research results showed that the two-contour fuzzy control method provided better results in stabilizing the inverted pendulum compared to traditional control methods. The inverted pendulum is a complex version of the mathematical pendulum. In this context, VR simulations prove to be an effective method for studying the mathematical pendulum and calculating its parameters [3].

Modeling physical phenomena is applied in many fields of science and technology. It is an essential tool for developing new technologies, optimizing engineering solutions, studying natural phenomena, and improving industrial processes.

Tarhi, Hasuni, Al Ibrahim, Lamri, and El Mahjoub in their research consider mathematical modeling in physics and the level of understanding of differential equations by students. The authors analyze models based on the laws of force and motion and highlight the importance of describing dynamic systems based on Newton's laws. The research results showed that mathematical modeling helps in the accurate understanding of physical laws and in building their mathematical descriptions [4]. Redish in his research discusses the importance of mathematical modeling in describing physical systems. The research results show that mathematical modeling of physical phenomena plays an important role in processing experimental data, conducting numerical modeling, and studying physical laws [5].

Virtual laboratories are becoming an important tool in the education system. They provide significant opportunities to improve the quality of teaching, develop research skills, and acquire practical knowledge. When developing virtual laboratories, it is crucial to select the right platform, create an efficient interface, and take user needs into account. In the future, these technologies will be widely used in the education system and will play an important role alongside traditional laboratories [6]. Putri, Muchlas, and Ishafit's work is an important study that shows the positive impact of virtual laboratories for distance learning on the educational process. The virtual laboratory they developed in fluid mechanics helped improve students' academic performance and assisted in acquiring practical knowledge [7]. The combination of virtual laboratories and innovative teaching methods demonstrates great potential and is one of the important directions that will contribute to the development of distance learning and STEM education in the future [8].

RESEARCH METHODS

In the course of the research, scientific articles were analyzed, and the research work was carried out. First of all, key words corresponding to the research topic were selected. Scientific articles were collected from the "Mendeley.com" database using key words such as "physical modeling," "virtual laboratory," "computer simulation," "digital modeling," and "Blender."

Computer Simulation Method: The computer simulation method allows the modeling, investigation, and visualization of physical phenomena such as nuclear power plants, hygrometers, 4-stroke engines, and the Fizeau experiment, helping to understand their operating principles.

Theoretical methods were also applied in the research. This method described the fundamental physical laws mathematically and provided the opportunity to analytically explain the results obtained from the model.

RESEARCH RESULTS

Modeling physical phenomena through the use of numerical methods allowed for the explanation of complex processes and the prediction of their dynamics. In particular, the modeling of nuclear power plants, 4-stroke engines, the Fizeau experiment, and hygrometers showed high results in explaining complex processes.

The 3D model of the nuclear power plant (NPP) serves as an engineering visualization that shows its main components and operating principles. This model describes the process of converting nuclear energy into heat and then generating electrical energy.

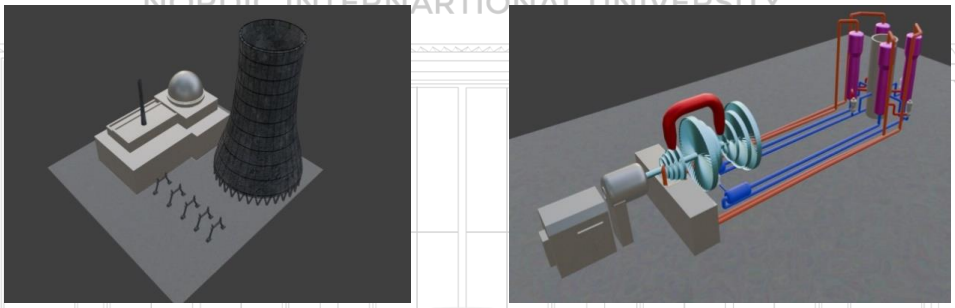

Figure 1. Model of a nuclear power plant

A 3D model of a nuclear power plant (NPP) is an important engineering tool used to visualize and study complex physical processes. With the help of this model, it is possible to fully understand the principle of operation of a NPP, study each stage of energy production and increase its efficiency.

Fizeau's experiment is based on the fact that light travels a certain distance and returns. Light pulses pass through a rotating disk and travel for a certain time interval, depending on its rotation speed. Knowing this time interval, the speed of light can be calculated.

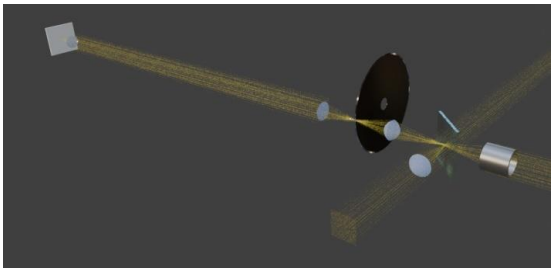

Figure 2. 3D model of the Fizeau experiment

The results of the Fizeau experiment simulation allow us to better understand the physical properties of light, study its propagation characteristics, and compare the speed of light in vacuum, gas, and liquid. In addition, these simulation methods help to study the refraction, reflection, and dispersion properties of light, and to assess the efficiency of various optical systems.

Modeling physical phenomena in virtual laboratories plays an important role in scientific research and education. This method helps students gain a deeper understanding of theoretical knowledge and provides the opportunity to improve laboratory skills. Additionally, virtual laboratories save time and resources while maintaining the authenticity of physical experiments.

A virtual laboratory is an innovative platform that allows scientific experiments and research to be conducted in a computer-based environment using digital technologies. It can replace or complement the function of real laboratory equipment. Virtual laboratories are widely used in education, scientific research, and engineering fields. With the help of virtual laboratories, important physical experiments, such as measuring the density of bodies, can be conducted in a safe and accessible environment.

Figure 3. VR lab: measuring the density of bodies

Virtual reality technologies allow to improve methods of measuring the density of bodies and make the learning process more effective. Through an interactive environment, users can understand physical laws and make accurate measurements, reducing errors. With the help of virtual laboratories, the quality of education increases and the possibilities of scientific research expand.

Modeling physical phenomena in virtual laboratories is an important direction in modern science and education. These technologies allow for the practical mastering of physical laws, improving scientific processes, and creating a safe laboratory environment. Moreover, virtual laboratories help save time and financial resources, accelerate research processes, and assist in understanding the principles of operation of complex physical systems through visualization. Research such as studying the mathematical pendulum, measuring the density of bodies, investigating the propagation of light (Fizeau experiment), and modeling atomic processes prove the effectiveness of these technologies.

CONCLUSION

Modeling physical phenomena and developing virtual laboratories is one of the key directions in modern science and education systems. These technologies, by combining theory and practice, allow for the improvement of scientific research and the enhancement of the teaching process. Virtual laboratories and digital modeling tools increase the efficiency of research and experiments while saving time and resources. Modeling physical phenomena and developing virtual laboratories is one of the key directions in modern science and education systems. These technologies, by combining theory and practice, allow for the improvement of scientific research and the enhancement of the teaching process. Virtual laboratories and digital modeling tools increase the efficiency of research and experiments while saving time and resources.

Thus, modeling physical phenomena and developing virtual laboratories is an integral part of science and engineering in the 21st century and will be one of the important factors in the future that influences socio-economic development, scientific innovations, and the introduction of new technologies.

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