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Advantages of Performing Mechanical Laboratory Work Virtually

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ABSTRACT

This article provides an analysis of the literature and programs on the advantages of performing virtual experiments and laboratory work in physics, and provides information on the implementation of virtual laboratory training using the Physics Education Technology (PhET) platform.

Introduction

Educating an independent, competent, competitive person adapted to the new conditions of society is one of the urgent issues of today's education system [1].

Introduction of information and communication technologies into the educational process, that is, digitalization of education, is one of the main ways to fulfill the above task [2].

Digitization of education allows future personnel to master information and communication technologies, as well as to accelerate the training of personnel in the field of specific sciences using information and communication technologies. Recently, a new term "Virtual educational laboratory" appeared in the field of using information and communication technologies in education.

According to the definition of V. V.Trukhin, a virtual laboratory is a software-hardware complex that allows experiments to be carried out without direct contact with a real installation or in the absence of them. In the first case, we are dealing with a remotely accessible laboratory setup, which includes the actual laboratory, software and hardware to control the setup and digitize the acquired data, as well as communication tools. In the second case, all processes are modeled using a computer [3].

The virtual educational laboratory is in accordance with the idea of open and distance education, and it reduces the relevance of problems related to material and technical support in the educational process.

Literature analysis

In order to determine the level, methods and perspectives of the use of virtual laboratory works in education, and to study their impact on the effectiveness of education, the existing experiences were thoroughly studied.

D.I. Troitsky states that by using virtual laboratory work, the level of learning of students has increased by 17.7%, and the time spent on laboratory work has decreased by 10-50% [4].

M.T. Taher also emphasizes that the use of virtual laboratory work is an effective tool for improving the knowledge of students, and suggests conducting virtual laboratory work together with traditional laboratory work, a combined teaching strategy [5].

Today, most of the virtual laboratory work used in the teaching of physics is in the form of a video, which involves the direct participation of the student, independent decision-making and research.

- independent selection of the necessary equipment from the equipment warehouse;
- formation of a laboratory work device;
- relative placement of device components (design);
- change the parameters of the studied object in a wide range;
- make changes to the device if necessary.
- aspects of the possibility of using modern measurement and control equipment are not taken into account [6]:

The use of information and communication technologies in the process of teaching physics, the demonstration of physical phenomena and processes that are technically very difficult or completely impossible to fully demonstrate in laboratory conditions, expanding the possibilities of conducting laboratory exercises, and various processes and phenomena allows simulation [7]. The main advantage of this technology is that it can be adapted to any lesson, effectively helps the teacher and the student. Another important situation is that there are some processes or phenomena that cannot be observed visually in laboratory conditions, for example, studying the ability of living organisms to see. In this case, computer simulations are invaluable, as they allow us to observe the optical processes occurring in the eye and at the same time obtain realistic results and draw conclusions. In the teaching of physics, it is desirable to widely use virtual experiments as an automated system along with the traditional laboratory.

Computers in physics classes, first of all, allow students to develop experimental and research activities. Computer simulation allows to create a bright, memorable dynamic image of physical experiments or events on the computer screen and opens wide opportunities for the teacher to improve lessons [8].

The greatest interest among students is related to computer models, through which it is possible to control the movements of objects on the computer screen by changing the values of numerical parameters based on a mathematical model. Some models provide an opportunity to observe time dependence graphs of a number of physical quantities describing the experiment simultaneously in dynamic mode during the experiment. Such models are especially valuable because students have great difficulty in drawing and reading graphs. Computer models allow almost "live" demonstration of real processes [9,10].

Virtual laboratory work is the similarity of laboratory equipment of science laboratories, but not replacement, real and virtual laboratories should work together and complement each other [10].

Taking into account the increase in the demand for physics laboratory equipment, the increase in tools, and the effective use of time by students, it is appropriate to use computer technologies in the organization and conduct of laboratory classes.

The use of virtual laboratory works can be carried out using one of the following four methods:

1. Using it as a virtual laboratory device for conducting laboratory training.
2. For short-term training before doing real laboratory work.
3. To strengthen students' knowledge by modeling the course of a certain process or the operation of a device in practical and seminar classes.
4. Use as a demonstration virtual program in theoretical lectures.

Research methodology

Virtual laboratories are directly used to organize lessons using animated demonstrations and virtual laboratory work. From such platforms, "Crocodile Physics", "Yenka Electricity and Magnetism", "Phun Physics", "Physics Education Technology" (PhET), "Physics at School" platforms designed for teaching physics were studied and studied. In teaching, the "Physics Education Technology" (PhET) platform was chosen, which is characterized by its simplicity and comprehensibility, and the inclusion of many animations and experiments related to the departments of physics.

Analysis and results

The "Physics Education Technology" (PhET) platform was created by K. Wiman, laureate of the 2001 Nobel Prize in natural sciences. The PhET platform includes models for various topics, created in Java and Macromedia flash.

The models presented on the PhET platform are Open Source and can be used by any user for free. The number of models in PhET is more than 100. They are able to conduct demonstration experiments related to physics, mathematics, chemistry, and organize and model virtual laboratory work. The PhET program corresponds to the state education standards of Uzbekistan and the literature used in educational institutions.

You can download the PhET program from the platform http://phet.colorado.edu. Models in the PhET program can be widely used as demonstration experiments in classes in physics, mathematics, chemistry and biology, and in organizing virtual laboratory sessions [11].

Figure 1. Overview of the PhET program.

In particular:

More than 90 on physics;

More than 10 in biology;

7 on mathematics;

There are more than 20 models related to chemistry.

The models presented in the program are translated not only in English, but also in more than 50 languages, in particular, 1 model is translated in Uzbek. If you want to translate the models presented in the program into Uzbek, you can do this without any difficulty. For this, there is a "Translated Sims" item on the official platform of the program, and you can go there and fill out a special account and select the appropriate model and translate it into Uzbek. In order to clarify the methods of using the program, we tried to clarify the process of conducting the laboratory work "Study of the movement of an object thrown obliquely to the horizon":

Labpoarotia work: study of the motion of an object thrown obliquely to the horizon

The purpose of the work: *"To study the motion of an object thrown at an angle to the horizon" in the PhET programming environment.*

Virtual elements: *roulette or indicator, scale ruler that changes the mass and diameter of the ball.*

Theoretical part

Motion of an object thrown obliquely to the horizon

Let's observe the movement of an object thrown with an initial speed ϑ_0 at an angle α to the horizon. It is required to find the time of flight for such objects, how high they rise, how far they fall, and their speed at any point of the trajectory.

It is divided into vertical (ϑ_y) and horizontal (ϑ_x) components of speed.

In that case:

$$\vartheta_y = \vartheta_0 \sin\alpha \qquad (1.1)$$

$$\vartheta_x = \vartheta_0 \cos\alpha \qquad (1.2)$$

The value of the vertical component of the velocity changes with time.

$$\vartheta_y = \vartheta_0 \sin\alpha - gt' \qquad (1.3)$$

At the point of maximum ascent of the object $\vartheta_y = 0 = \vartheta_0 \sin\alpha - gt'$, the object rises during the time $t' = \frac{\vartheta_0 \sin\alpha}{g}$. Since an object thrown vertically upwards takes as much time to fall as it went up, the time of flight of the object is found by the formula below.

$$t = 2t' = \frac{2\vartheta_0 \sin\alpha}{g} \qquad (1.4)$$

The horizontal component of velocity is a constant quantity. Therefore, the flight distance of the object is found by this formula below.

$$s_x = \vartheta_x \cdot t = \frac{2\vartheta_0^2 \cos\alpha \cdot \sin\alpha}{g} = \frac{\vartheta_0^2 \sin 2\alpha}{g} \qquad (1.5)$$

The lifting height of the object is calculated based on the formula $h = \vartheta_{y0} t' - \frac{gt'^2}{2}$.

This follows from the fact that $\vartheta_{y0} = \vartheta_0 \sin\alpha$, $t' = \dfrac{\vartheta_0 \sin\alpha}{g}$ is in the formula.

$$h = \frac{\vartheta_0^2 \sin^2\alpha}{2g} \qquad (1.6)$$

The speed at any point of the motion trajectory is calculated as follows.

$$\vartheta = \sqrt{\vartheta_x^2 + \vartheta_y^2} = \sqrt{\vartheta_0^2 \cos^2\alpha + (\vartheta_0 \sin\alpha - gt)^2} \qquad (1.7)$$

It should be noted that all the expressions given above are valid without taking into account air resistance. ($\vartheta = \vartheta_0$, $\alpha' = \alpha$). (If air resistance is not taken into account, an object thrown obliquely to the horizon will fall back to the ground at the same angle and speed as it was thrown).

Order of work:

1. Introduction to the PhET program. To do this, type PhET in the browser and select the Colorado.edu platform (Figure 2).

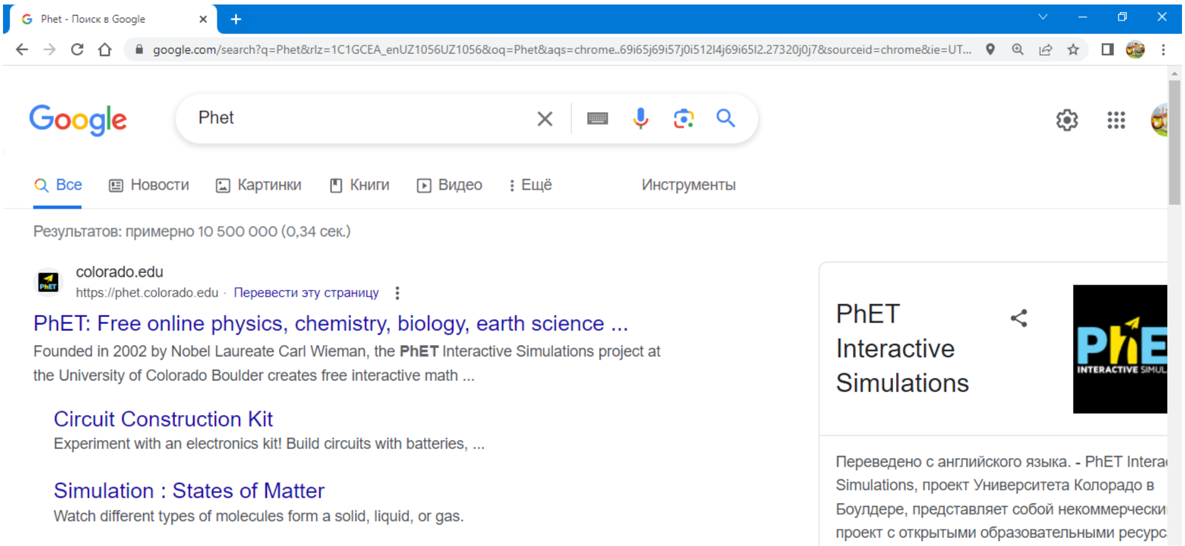

Figure 2. Introduction to the PhET program

2. From the contents of the Phet program, select the Department of Physics (Fig. 3).

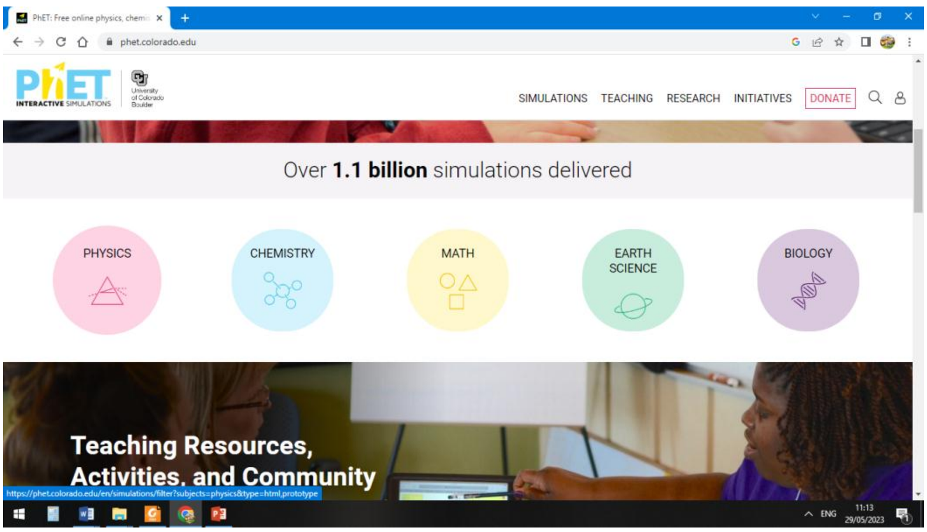

Figure 3. Contents of Phet program Department of Physics

3. Select the "Projectile motion" window from the "Motion" section (Fig. 4).

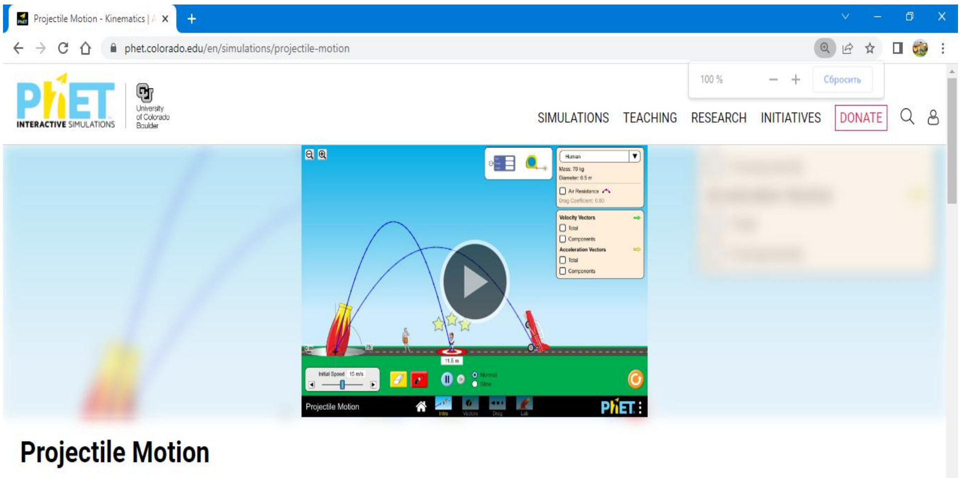

Figure 4. Projectile motion window from the Motion section

4. Start the simulation by setting the firing angle of the projectile launcher in the model to 30° (Fig. 5).

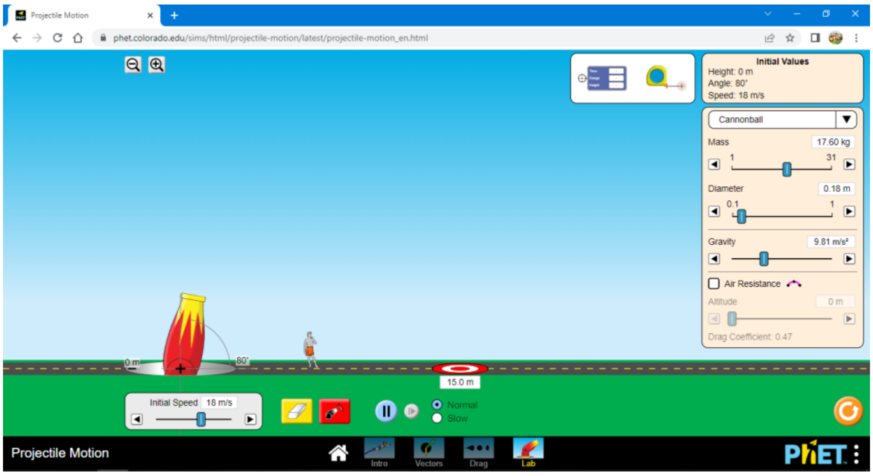

Figure 5. Run the simulation.

5. By pressing the projectile firing button, the projectile is fired and its movement is observed (Fig. 6).

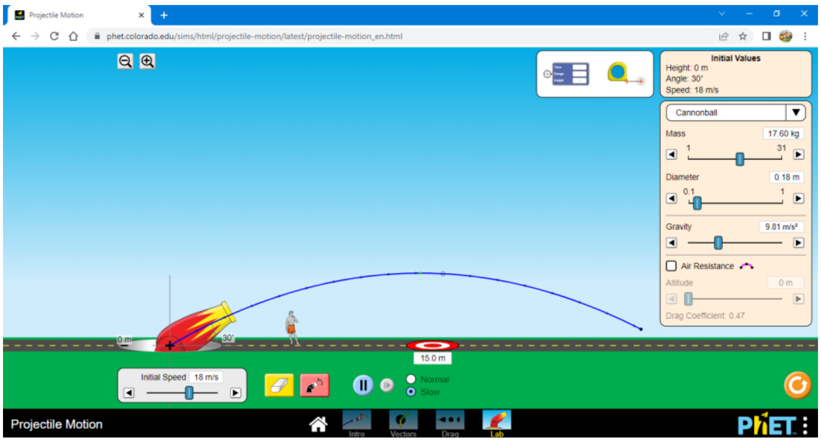

Figure 6. Tracking the movement of the projectile.

6. The landing place of the ball is determined and the flight distance is measured. For this, the above roulette is used.

7. The experiment is repeated at least 3 times as above.
8. The experiment is repeated by setting the projectile firing angle to 45°.
9. The value of the calculated quantities is written in the following table.

Firing angle	Experiment	l, flight distance, (m)	$l_{o'rt}$, (m)	Δl, (m)	$\Delta l_{o'rt}$, (m)
30^o	1-experiment				
	2-experiment				
	3- experiment				
45^o	1- experiment				
	2- experiment				
	3- experiment				

Conclusions and suggestions

The conducted research shows that the need for virtual laboratory work is very high in our Republic. This need should be met at the expense of globally tested, effective programs. In the teaching of physics, it is necessary to include virtual laboratory programs as an addition to real laboratory work in the educational process. This will prevent gaps in students' practical skills, and significantly improve the quality of education. In addition, it will be possible to use virtual laboratory programs in distance learning and in students' free time outside of school.

We suggest using the PhET platform as an effective tool for organizing virtual laboratory work on physics based on research results. The interface of this platform is simple and clear, and the options are extensive. In the future, we recommend conducting research on the development and implementation of demonstration-experiments and virtual laboratory works for the physics course using the PhET platform.

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