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Research Article

IMPROVING THE METHOD OF EFFECTIVE TEACHING FOR MODELLING AND PERFORMING VIRTUAL LABORATORY WORKS IN PHYSICS

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ABSTRACT

The paper presents the results of research into the development of a method for teaching students the processes of computer modeling of the laws of physical phenomena during laboratory work. The principles of students' actions in introducing initial data and carrying out experiments in order to observe laws of physics: solid bodies collision, absolutely elastic impact are described.

KEYWORDS

Collisions, solids, gravitational constant, functional animation, modelling.

INTRODUCTION

One of the most promising uses of information technology in physics education is computer modelling of physical phenomena and processes. At present, computer models are used in almost all academic disciplines. The use of such computer possibilities as fast counting, mathematical modelling, the use of animation and computer graphics, a variety of colour schemes allows the teacher to make the teaching process in physics more interesting, diverse and effective. The use of computer technology has significantly expanded the possibilities of the lecture experiment, allowing to simulate various physical processes and phenomena that are technically very difficult or simply impossible to demonstrate in the laboratory [12]. The use of computer animation and a variety of colours always increases the interest of students in the lesson.

It is known that among the natural phenomena studied in a high school physics course, there are processes which direct observation within the limits of practical training is difficult or demands the special equipment. The computer model has found wide use in laboratory practice, allowing to carry out calculations of the measured value on the basis of the received experimental data, to find errors of measurement, to operate a course of carrying out of experiment.

Computer models are often easier and more convenient to investigate, and they allow computational experiments to be carried out that are difficult to perform in reality or may give unpredictable results. Computer simulations of physics experiments offer great opportunities, allowing one to obtain more complete information about the phenomenon being studied, to extend the understanding of the unseen processes occurring in the depth of the experiment, and also allowing for a visual comparison of results obtained using different experimental investigations.

Mission statement

But today, due to the progress of microprocessor technology and speed of computers, visual representation of such phenomena is possible by multiplication methods during solution of mathematical model equations, and "observed" parameters of the phenomenon will be completely conditioned by "natural" values of initial data. This is implemented in the proposed laboratory works, performed in the dialog mode on the computer.

At the psychological level, computer-based learning creates disturbances of varying degrees which are related to the difficulty of revising the conceptual apparatus of describing different levels of reflection. It should be noted that computer technology allows:

 Continuous use of computer technology throughout the training period;

 comprehensive coverage of the learning process;

 consistency and uniformity in technical, programme, organisational and teaching support;

 replication of elements of the technology with a view to mass dissemination;

 adaptation to different application conditions.

Literature review. In order to define the role and place of the computer in the structure of pedagogical activity, as the researchers of this problem believe 3,5,9,11,12, to better "coordinate" the human and the logic in this complex interaction, it is necessary to structure the teacher's activity in a reasonable and quite detailed way. This structuring is proposed using the concept of "didactic task". All didactic tasks performed by a teacher are divided into three main classes:

- on the elements of learning;
- on the elements of the lesson structure;
- on the intellectual activities and skills to be developed.

It should be noted that theoretical and practical aspects of didactic task implementation using computers have not been sufficiently developed. In solving this methodological problem, a number of questions arise, which require an in-depth study of students' learning activity under computer learning conditions and clarification of the knowledge and skills they should master in the learning process, in particular, when teaching physics [3, p.79].

In order to implement the above provisions in a methodological aspect, in particular for effective assimilation of the basic ideas and concepts of fundamental physics topics, it is necessary to correctly

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present the didactic possibilities of the teaching tools used, including computer tools and learning systems.

In doing so, the computer performs the following basic functions:

- Simulation modelling of the objects and phenomena under study;

- measurement and implementation of physical process parameters;

- processing the results of a physical experiment.

One of the main uses of computer technology as a learning tool is computer modelling of the phenomena and processes being studied.

At the same time, the methodology developed for the use of computer models of physical phenomena is still poorly applied in the educational process, which is due to the lack of appropriate methods for its implementation. There is, perhaps, no science or branch of knowledge which does not speak about models and does not deal with modelling. Application of computers has raised modelling and its content to a qualitatively new level [5, 7, 10, 11,12 etc.].

The desirability of using a computer for the development and widespread use of various models of physical phenomena in the teaching and learning process is based on the following factors:

- the large role and diverse functions of models not only in science, but also in the practical teaching of engineering tasks;
- The extensive capabilities of modern computers to simulate complex, dangerous and costly fixtures that cannot be made under real conditions in the laboratory;
- Intensive introduction of computer technology into the teaching process;
- positive experiences with the use of computer-based training models of physical phenomena and processes.

RESEARCH METHODOLOGY

Guide to virtual laboratory work in physics.

We have developed and offered teaching guidelines and manuals for all sections of physics for laboratory work. Laboratory works can consist of physical stands and virtual laboratories. For example, let's consider a virtual laboratory work absolutely elastic ball impact.

In the classroom there is a learning of physical laws in practice. As minimal examples of virtual laboratories we recommend the following topics on the section "Mechanics": the law of conservation of momentum, the law of conservation of mechanical energy, impact of solid bodies, world gravitation, cosmic velocities, etc. The present work proposes a method of stage-by-stage simulation of physical phenomena in order to reveal the essence and regularity in students, the main concepts and ideas that will contribute to the full assimilation of this material.

During the study of laws of absolutely elastic ball impact, a particular case of body collision, in mechanics of solid bodies, collisions of elementary particles, etc. it is considered expedient to propose theoretical concepts, developed quite fully and widely known. Laws of conservation of angular momentum for the closed system and mechanical energy for the conservative system are the direct consequence of laws of motion [2, 4-7]. By simple algebraic transformations, based on Newton's 2nd law, it is possible to receive that in any closed system

$$\frac{d}{dt}\sum \overrightarrow{m_i \upsilon_i} = 0 \Rightarrow \sum \overrightarrow{m_i \upsilon_i} = \text{const} \quad or \quad P_{системы} = \text{const},$$

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and from the definition of mechanical work and kinetic energy: the mechanical energy of a closed system, in which there are no dissipative forces, remains constant during motion.

It is the fulfillment of these two fundamental laws of nature that are tested on the example of elastic collision of balls during the laboratory work. Work on mathematical modeling of process of absolutely elastic impact (k=1) of two balls is conducted on the computer in a dialogue mode, i.e. all messages are given on the display screen (see Fig. 1).

The laboratory work involves both learning tasks to check the laws of conservation, as well as play ("hitting" a conditional pocket with one of the balls).

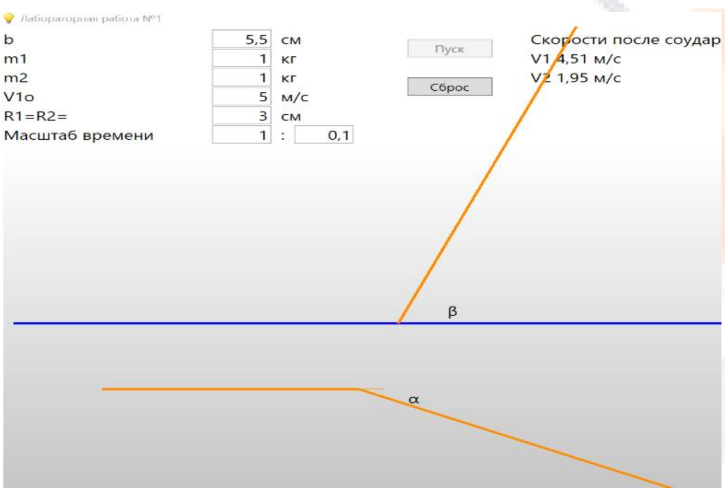

Figure 1. Screenshot of the execution screen of the "Absolute elastic ball impact" program (the "experimental scatter" of the "measured" ball velocities after the impact can be seen; scaling only by time-of-flight).

The law of conservation of momentum is a direct consequence of the laws of motion [2, 4-7]. We would like to point out that in lecture classes there is especially little time devoted to studying the law of conservation of momentum of a closed system.

Suppose a system of several material points that interact with each other but are not externally affected by other bodies. A system that includes all interacting bodies (so that none of the bodies of the system is acted upon by other bodies except those included in the system) is called a closed system. The forces acting between the bodies forming a closed system are called internal forces (figure 2).

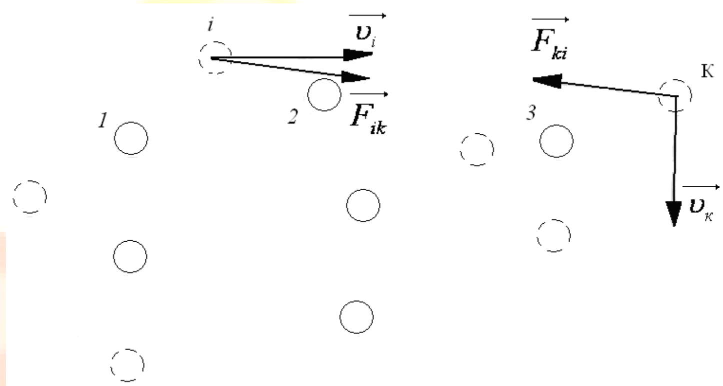

Figure 2. Internal forces acting between bodies in a closed system.

Imagine a closed system consisting of material points, with masses of

m_1 , m_2 , m_3, ... Let the velocities of these points $\vec{V}_1, \vec{V}_2, \ldots \vec{V}_i$ ... and the internal forces acting between them, $\vec{F}_{12}, \vec{F}_{13}$ ... $\vec{F}_{i\kappa}$ ($\vec{F}_{i\kappa}$ is the force acting on body ***i*** from body ***k***). Let us write the equation of Newton's second law for each of these points:

$$\frac{d}{dt}(\overrightarrow{m_1\upsilon_1}) = \vec{F}_{12} + \vec{F}_{13} + \ldots;$$

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$$\frac{d}{dt}(\overrightarrow{m_2\upsilon_2}) = \overrightarrow{F_{21}} + \overrightarrow{F_{23}} + \ldots;$$

$$\frac{d}{dt}(\overrightarrow{m_3\upsilon_3}) = \overrightarrow{F_{31}} + \overrightarrow{F_{32}} + \ldots$$

Adding up all these equations, we get the time derivative of the total amount of motion on the left and the sum of all forces acting in the system on the right. But since the system is closed, the sum of all forces in it is zero. Indeed, in this sum the forces $\overrightarrow{F_{12}}$ и $\overrightarrow{F_{21}}$, $\overrightarrow{F_{23}}$ и $\overrightarrow{F_{32}}$, etc. will meet in pairs, and according to Newton's third law, $-\overrightarrow{F_{ik}} = \overrightarrow{F_{ki}}$, so the total sum of forces in a closed system is always equal to zero. Consequently, in any closed system

$$\frac{d}{dt}\sum \overrightarrow{m_i\upsilon_i} = 0 \Rightarrow \sum \overrightarrow{m_i\upsilon_i} = \text{const}$$ or

$$P_{системы} = \text{const}\ ,$$

i.e. the total amount of motion of a closed system is a constant. The latter is a universal law of nature, ***the law of conservation of momentum in a closed system.***

If the system is not closed, i.e. there are ***external*** forces acting on the bodies of the system $\overrightarrow{\Phi_1}, \overrightarrow{\Phi_2}$, then

$$\frac{d}{dt}(\overrightarrow{m_1\upsilon_1}) = \overrightarrow{F_{12}} + \overrightarrow{F_{13}} + \ldots\overrightarrow{\Phi_1};$$

$$\frac{d}{dt}(\overrightarrow{m_2\upsilon_2}) = \overrightarrow{F_{21}} + \overrightarrow{F_{23}} + \ldots\overrightarrow{\Phi_2}.$$

Add up the equations of motion for all points, the sum of all internal forces $\overrightarrow{F_{ik}}$ will still be zero. Hence,

$$\frac{d}{dt}\sum \overrightarrow{m_i\upsilon} = \frac{d}{dt}P_{системы} = \sum \overrightarrow{\Phi_i}.$$

The derivative of the total amount of motion of a system of bodies (the momentum of the system of bodies) is equal to the geometric sum of all external forces acting on the system. External (and only external) forces change the total amount of motion of the system.

The following is one of the theoretical questions in the study of the law of conservation of mechanical energy.

It is known that if the work of forces in moving a body between any two points in a central field of forces does not depend on the shape of the path, but only on the position of these points, then such a field is called ***potential***; and the forces are called ***conservative***. Gravitational forces, Coulomb forces of interaction of point charges are conservative forces. Frictional and drag forces are not conservative forces; they are called ***dissipative forces.*** The total work of all internal dissipative forces of the system is always negative.

In a potential field, when a particle moves from various points B_i **to** a fixed point o, work is done which depends only on the radius vectors $\vec{r_i}$ of points B_i . ***The*** function ***P(r), which*** depends only on ***r*** and determines the work to move a particle in a potential

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field, is called ***the potential energy*** of that particle in that field[1]. The potential energy of a particle is defined to a constant value.

The work of forces in a potential field is equal to the difference in potential energies at the initial and final positions of the particle.

Another type of mechanical energy is kinetic energy.

Kinetic energy is a physical quantity defined by the work that forces must do when braking a moving body. Kinetic energy is a quantitative measure of mechanical motion; it depends on the relative speed.

At low speeds ***v***, when the ratio

v/c = β´,

where **c** is the speed of light in a vacuum, much less than unity, kinetic energy ***of translational***[2] ***motion*** of a body

$$K = \frac{1}{2} m_0 \cdot v^2,$$

where m_0 is the rest mass of the body.

At high speeds, when β approaches unity, the kinetic energy is equal:

$$K = \frac{m_0 c^2}{\sqrt{1-\beta^2}} - m_0 c^2,$$

where $m_0 c^2$ is the resting energy.

The total mechanical energy of a system is the sum of the kinetic and potential energies of all the particles in that system:

E=K+P

The change in the mechanical energy of the system is equal to the algebraic sum of the work of the external forces and all the internal dissipative forces:

$$E_2 - E_1 = A - A_Д,$$

where E_2 is the final energy value of the system;

E_1 is its initial energy;

A is the work of external forces;

Andд is the total work of internal dissipative forces (always negative!).

The law of conservation of mechanical energy in an inertial reference frame: The mechanical energy of a closed system, in which there are no dissipative forces, remains constant during motion. In general, energy is a single quantitative measure of various forms of motion (and not just mechanical). The law of conservation of energy is the fundamental law of nature for all forms of energy: mechanical, internal, nuclear, etc.

[1] Potential energy of a body in the Earth's gravitational field:

$P = -\gamma \cdot Mm/R$, where γ is the gravitational constant, ***M*** is the mass of the Earth, ***m*** is the mass of the body, ***R*** is the distance from the centre of the Earth to the centre of gravity of the body. (In physics, potential energy of gravitational forces is assumed to be negative and potential energy of repulsive forces to be positive; hence the minus sign here).

[2] The kinetic energy ***of a rotating*** body:

$K = \frac{1}{2} I\omega^2$, where ***I*** is the moment of inertia, ω is the angular velocity.

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Energy does not come out of nowhere and does not disappear: it can change from one form to another.

When a body is moved a short distance from the Earth's surface, the Earth's gravitational field is assumed to be homogeneous (as the height h is much smaller than the Earth's radius).

In a homogeneous field, the potential energy of a body

P = mgh,

where *m* is the mass of the body;

g is the acceleration of gravity;

h is the height of the body, counted from some reference level at which the value of the potential energy is assumed to be zero.

The surface of the Earth, for example, can serve as such a reference level.

The unit of energy and work is the joule (J), the unit of power is the watt (W).

1 J is equal to the work done by a force of 1 N when moving a body 1 m forward.

1 W is equal to the power at which 1 J work is done in 1 s.

Thus, in closed systems in which only conservative forces act, the total mechanical energy is conserved during all evolutions of the system, or

$$E = K + \Pi = \sum_{i=1}^{N} K_i + \sum_{i=1}^{N} \Pi_i = const$$

, will be written in the form of

$$K = \sum_{i=1}^{N} K_i = \sum_{i=1}^{N} \frac{m_i \upsilon_i^2}{2}, \quad \Pi = \sum \Pi_i = \sum m_i g h_i$$

.

When considering a perfectly elastic impact, the system is often described on a plane - then, obviously, there is no change in potential energy.

$P_1 = P_2$ and $\Delta P = 0$.

When two solid bodies collide, only the relative velocity of both bodies plays a role, so one of the bodies can be regarded as being at rest and only the motion of the other can be observed. At the moment both bodies touch, a plane tangent to both bodies can be drawn to the point of contact. The line perpendicular to this plane and passing through the point of contact is called the line or normal of impact.

If the line of impact passes through the centre of gravity of both bodies, the impact is called ***central***. An impact is called ***direct*** if the body making the impact is relative to the body receiving the impact in a forward motion in the direction of the impact normal; otherwise, the impact is called ***oblique***.

Bodies cannot be assumed to ***be perfectly rigid*** during impact. The change in shape of the impacting surfaces is important to the impact process that it cannot be neglected. Two periods can be distinguished in an impact. The first period is called the touching of both bodies (see Figure 3, b). At this point, flattening of the surfaces in contact occurs. By the end of the first period the flattening, hence the convergence of both bodies reaches a maximum, the touching point of both those has the same velocity. Then the second period begins, during which the flattening disappears completely or only partly. This period lasts till the moment of divergence of both bodies (Fig. 3, c).

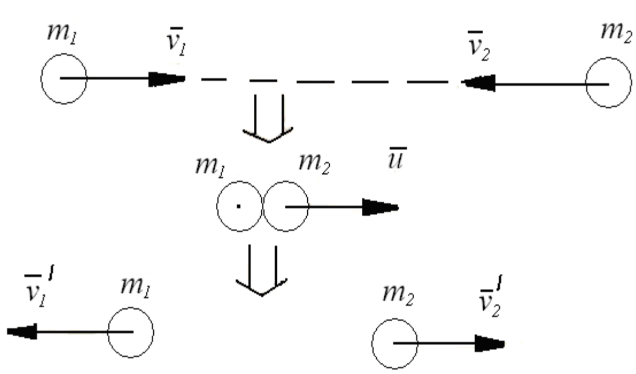

Figure 3. m_1 , m_2 , v_1 , v_2 - masses and velocities of bodies respectively

(upper dash indicates post-impact velocities), *u* - velocities of bodies at the time of contact.

The impact force **F** is usually only effective for a very short time. It increases during the first period usually to a large size and falls to zero during the second period.

For the impact process, the law of motion (momentum) is valid. For the change of momentum (***P=m* v)*** we get from Newton's II law:

$$\bar{F} = m\bar{a} = m\frac{d\bar{v}}{dt},$$

$$\overrightarrow{m\Delta\upsilon} = m(\vec{\upsilon}' - \vec{\upsilon}) = \int_t^{t'} \vec{F}dt = \Delta\vec{P}.$$

The time integral of the force **F** is called the momentum of the force. The momentum of the force during the impact time ***t'-t*** is equal to the increment ΔP - the quantity of motion of the striking body of mass *m* .

Compared to the impact forces for the time of the impact process, all the effects of other forces, e.g. weight, can be neglected, i.e. when a body is struck, it can be seen as

Straight center kick.

In a direct central impact, the line of impact passes through the center of gravity of both bodies, and the relative motion is translational motion parallel to the line of impact; for example, the impact of two balls is parallel to the line passing through their centers. Let us denote by m_1 , m_2 the masses of both bodies, v_1 , v_2 their velocities before the beginning of the impact, v_1' , v_2' the velocities by the end of the impact. We obtain

$$m_1\vec{\upsilon}_1 + m_2\vec{\upsilon}_2 = m_1\vec{\upsilon}_1' + m_2\vec{\upsilon}_2' ;$$

$$\Delta\vec{P}_1 = m_1(\vec{\upsilon}_1' - \vec{\upsilon}_1) = m_2(\vec{\upsilon}_2' - \vec{\upsilon}_2) = \Delta\vec{P}_2 ,$$

i.e. the change in momentum of the bodies *is the same*!

What are the circumstances of a totally inelastic impact**:**

$v_1' = v_2' = u$ - total velocity after impact

$$\vec{u} = \frac{m_1\vec{\upsilon}_1 + m_2\vec{\upsilon}_2}{m_1 + m_2}$$

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$$\Delta K = \frac{m_1}{2}(\overline{u^2} - \overline{\upsilon_1^2}) + \frac{m_2}{2}(\overline{u^2} - \overline{\upsilon_2^2}) = \frac{m_1 m_2}{m_1 + m_2} \cdot \frac{(\upsilon_1 - \upsilon_2)^2}{2}$$

1. Under what circumstances is an absolutely elastic impact:

$$\overrightarrow{\upsilon_1^{/}} = \frac{(m_1 - m_2)\overline{\upsilon_1} + 2m_2\overrightarrow{\upsilon_2}}{m_1 + m_2};$$

$$\overrightarrow{\upsilon_2^{/}} = \frac{2m_1\overrightarrow{\upsilon_1} - (m_1 - m_2)\overline{\upsilon_2}}{m_1 + m_2};$$

$\Delta K = 0$ (show yourself)

If $m_1 = m_2$, then $v_1^{/} = v_2$, $v_2^{/} = v_1$,

If $v_2 = 0$, then

$$\overrightarrow{\upsilon_1^{/}} = \frac{(m_1 - m_2)\overrightarrow{\upsilon_1}}{m_1 + m_2}, \quad \overrightarrow{\upsilon_2^{/}} = \frac{2m_1\overrightarrow{\upsilon_1}}{m_1 + m_2}.$$

ANALYSIS AND RESULTS

Computer simulation is one of the most effective methods of teaching physics laboratory work. One of the most effective methods of teaching students to perform virtual laboratory works is computer simulation of physical phenomena and processes.

I would like to point out that laboratory work in a physics course in higher education institutions plays an important role both in understanding the studied physical phenomena and laws, in forming fundamental ideas about material nature, and in acquiring skills and abilities included in the curriculum for qualification training.

The ability to correctly set up an experimental problem, formulate its purpose and method of obtaining results, as well as the ability to correctly conduct measurements, process and interpret the results in the form of a comprehensive conclusion, is one of the basic skills of a competent engineer, because modern production is unthinkable without increasing volumes of telemetric data from all kinds of sensors characterizing technological (electrical, mainly) process parameters and technical parameters of machines and units.

Each laboratory work will be carried out by a group of up to 2 students. If there are 24 students in a group, there will be no more than 12 students in a subgroup. The topics of the laboratory work are communicated to the students at least one week before the class. The instructor evaluates the laboratory work and the defense of the work.

When starting the laboratory work, you should study the essence of the physical phenomenon in question and its theory according to the recommended textbook or lecture material. Great care must be taken to familiarize yourself with the instruments and the setup. The latter should be done very carefully, making sure that no extraneous influences distort the results of the observation.

The mathematical modelling of a perfectly elastic impact process (*k=1*) of two balls is carried out on the computer in dialogue mode, i.e. all messages are displayed on the display screen. The method of phased

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learning consists in performing the tasks one by one as a task algorithm and consists in the following:

1. Carefully examine the state of the screen, i.e. the program message.

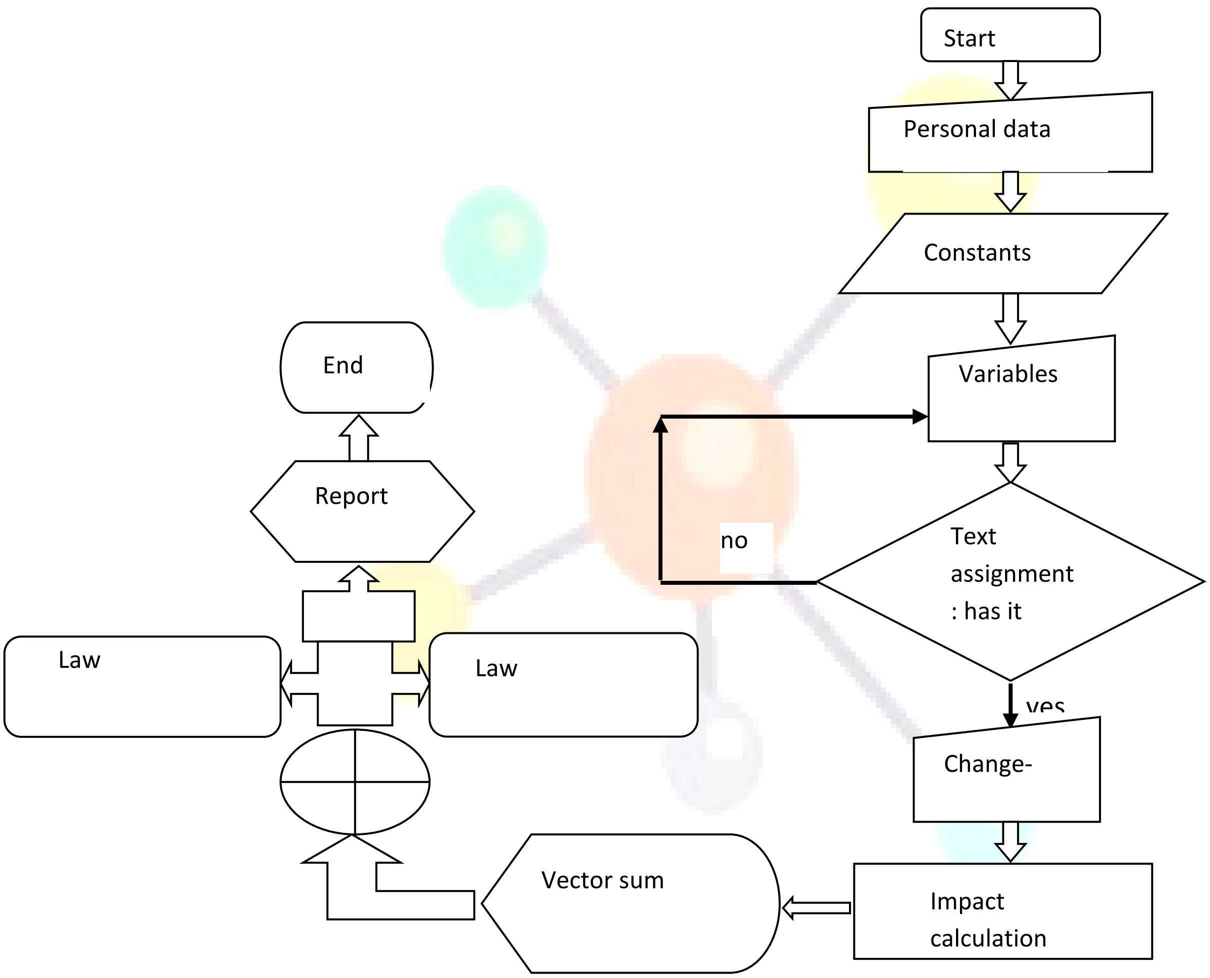

Fig.4. Programme algorithm for the subject: "Absolute elastic ball impact".

2. Practice finding the "aiming" distance ***b so*** that the 1st or 2nd, (set by the teacher) ball hits the "pocket" (fig. 5) after the collision.

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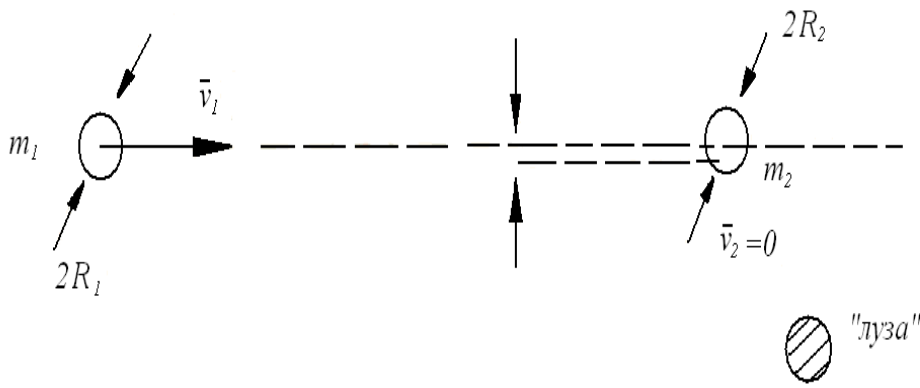

Figure 5. Recommendations for selecting the "sighting" distance *b*

3. Check that the law of conservation of energy is fulfilled. To do this, construct Table 1.1.

Table 1.1

Checking the law of conservation of energy

b (fraction of R_1+R_2)	0	0,2	0,3	0,4	0,5	0,6	0,7	1,0	Average value
b, cm									
$v_1^/$, m/s									
$v_2^/$, m/s									
$K^/$, J									
$\Delta K^/$, J									

Notes:

1. The values of ***b*** are stated in units (R_1+R_2), *i.e.* ***b=0.2*** means ***b=0.2* (R1+R2).***
2. Initial data: ***m1 = N kg, m2 = 2N kg, R1 = N cm, R2 = 2N cm, v1 = N m/s, v2 = 0 m/s,*** where **N** is the number of the student in the list in the journal.
3. The total kinetic energy of the bodies after impact is compared with the initial energy $m_1(V_1)^2/2$

4. Check whether the law of conservation of momentum is fulfilled by completing Table 1.2.

Table 1.2

Checking the law of conservation of momentum

b (fraction of R_1+R_2)	0	0,2	0,3	0,4	0,5	0,6	0,7	1,0	Average value

b, cm									
$v_1^{/}$, m/s									
$v_2^{/}$, m/s									
α, deg									
β, deg									
$P_1^{/}$, kg*m/s									
$P_2^{/}$, kg*m/s									
$P^{/} = P_1^{/} + P_2^{/}$, kg*m/s									
$\Delta P^{/}$, kg*m/s									

CONCLUSIONS

Thus, the virtual physical laboratory makes it possible not only to "visualize" the invisible, but also to describe numerically the processes taking place in micro- and macrocosm. And also, in the conditions of increasing methods of distance education, preventively to provide with a laboratory practice for students of physical faculties of classical universities and technical high schools, putting in the same conditions different fundamental or applied problems.

The possibilities of modern electronic technology for improving educational physics experiments are not limited to computational experiments and processing the results of experiments by means of personal computers. It should be noted that the widespread use of electronic technology will, on the one hand, improve the quality of knowledge and skills acquired in the physics laboratory and, on the other hand, contribute to the goals of modern polytechnic education.

REFERENCES

1. Trofimova T.I. Course of physics [Text]: textbook / T.I. Trofimova. - 19th ed. - Moscow: Academy, 2012. – 560 p.
2. Savelyev I.V. Course of general physics [Text]: textbook in 4 vols / I.V. Savelyev; ed. by V.I. Savelyev. - Moscow: KIORUS, 2009 - 856 p.
3. Alexandrov G.N. Programmed Learning and New Information Technologies of Teaching /Informatics and Education. -1993. -№5. -P. 19.
4. Detlaf A.A., Yavorsky B.M. Course of physics [Text]: textbook / A.A. Detlaf, B.M. Yavorsky. - Ed. 4-th revised edition. - Moscow: Higher School, 2002. - 718 p.: illustration.
5. A.M. Kasimakhunova, G. A. Umarova. Development of methods for effective learning in modeling the

properties of semiconductors for research works. Scientific Bulletin of Namangan State University. ISSN 2181-0427, journal.namdu, uz.№7, 2022г. .pp. 320-326.

6. Measurements of physical quantities . Methodical manual for students of all specialities and forms of training. Authors: R.R. Abdulmanov, L.I. Kaganov - Samara: SamGAPS, 2006 - 25 p.
7. Umarova G.A. Improvement of Quantum Physics Teaching Methodology on the Basis of Computer Technologies in General Education Schools. Dissertation for the degree of candidate of pedagogical sciences. -Tashkent, Tashkent State Pedagogical University, - 2008. -150 p.
8. Suleymanov R.N. To the question of developing virtual laboratory works / Suleymanov R.N. In the book: New educational technologies in higher education. Collection of abstracts and reports of conference participants. editor: A.V. Porotnikova.- Ekaterinburg: Publishing house of UrSU, 2.
9. Mashbitz E.I. Psychological and Pedagogical Problems of Computerisation of Learning. -M.: Pedagogy, 1988. – 35p.
10. Vishtynetsky E.I. Issues of Information Technology Application in Education and Training //Information Technologies. -1998. -№2. -P.32.
11. Joraev M., Umarova G.A. Application of computer technology in teaching fundamental experiments of quantum physics in a secondary school //Pedagogik ta'lim. -Tashkent, 2008. -№2. -P.61-64.
12. Kavtrev A.F. Experience of using computer models. Physics at School and University" -Saint Petersburg: Obrazovaniye, 1998. -P.102.