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LABORATORY WORKSHOP IN PHYSICS BASED ON COMPUTER SIMULATIONS MS EXCEL

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ABSTRACT
The article shows the possibility of conducting a laboratory workshop with only computer equipment and presents the developed laboratory work on various topics of the general physics course.

Keywords: laboratory-practical lesson, computer simulation, methods of teaching physics, interactive learning, distance learning

INTRODUCTION
Modern Internet technologies make it possible to develop distance learning, which can be considered not only as a separate direction, but also as an addition to full-time education [1]. Currently, educational materials include not only books and guidelines, but also video lectures, online tests, as well as various interactive systems for modeling a physical experiment [2]. One of the main problems in the implementation of distance education is the conduct of a laboratory workshop remotely. There are two ways to compensate for the absence of a student near a real laboratory setup: watching a video recording of an experiment, conducting an interactive experiment. If in the first case the student can observe a real experiment, but does not take part in it, then in the second case the student participates both in setting up a virtual experiment and in the measurement process. The implementation of interactivity in modern conditions of distance learning is possible only with the use of computer models. The disadvantage of the computer model associated with the replacement of a real experiment by a virtual one is compensated by the possibility of repeating the experiment many times at any time without causing harm to the facility.

DEVELOPMENT OF LABORATORY WORKS
Virtual research can be carried out in three ways: animation of physical processes, an interactive constructor of a physical experiment, a virtual laboratory setup. In the first case, the user can observe the experiment from different angles without the ability to influence the conditions of the experiment. In the second case, the user has the

opportunity to engage in research work, controlling all the stages and conditions of the experiment. In the third case, the user has the opportunity to perform laboratory work in strict accordance with the guidelines. There are different options for implementing virtual research (VLR): applications that require only a browser with pre-installed modules; an application that provides for installation on a PC; an application that requires additional software to be installed.

From the point of view of obtaining experimental data, VLR can be divided into client-server applications and stand-alone applications. In the first case, data exchange between the client computer and the server is assumed. In the second case, the data is stored only on the computer. This article will discuss options for implementing standalone applications. Depending on the choice of development environment, the application may need to install additional software. In this article, we will consider the most common development tools for creating VLR: Wolfram Mathematica, VPython, Unity, Node.JS, QT QML, Visual Pascal, MS Visual Studio C ++.

The experience of conducting laboratory-practical classes (LPZ) [1, 2] shows that for better assimilation of the material covered by students, it is necessary to have visual methods that allow a detailed discussion of the physical laws and processes considered in lectures. As a result of the fact that the equipment of the audience does not always allow laboratory work to be carried out in real conditions, it becomes necessary to create laboratory work, for which the computer equipment of the audience is sufficient [3 - 5]. This method of conducting laboratory and practical classes is especially relevant when conducting classes remotely or in distance learning.

The choice of a software environment for conducting laboratory and practical classes is determined by a number of factors - the degree of training of students in the field of computer literacy; the possibility (including financial) of installing the necessary software; visibility and variability of tasks, which may be limited in the case of the acquisition of the author's virtual laboratory complex. The experience of using such programming systems as Mathcad, Matlab and the like in the process of conducting classes at the engineering and technical faculties of universities and communications has shown their convenience only when used in lectures as good illustrative material, since the programs are installed only on the lecturer's PC. Despite the fact that the interface of these programs is intuitive and the calculation formulas are written almost in the usual physical form, cadets experience difficulties in the process of work during laboratory and practical classes, since the study of systems such as Mathcad is not included in the computer science courses at school and universities not in physics. - mathematical profile. Drawing up a calculation formula and introducing the variability of parameters, even in simple cases, takes students a lot of time. As a result, after the analysis, in order to combine economy, visibility, efficiency, and ease of control over the parameters of the studied physical processes, the authors decided to choose the EXCEL environment as the basis for conducting laboratory and practical classes in a virtual version. EXCEL, like other components of Microsoft Office, is well known to students and cadets who are studying in the first or second year, from computer science lessons at school and additionally studied at the university. Thus, the choice of the Microsoft Office environment for creating tests and RGR is determined by the following factors:

❖ Firstly, this software was previously installed on all computers in our laboratory, which allowed us to save money on the purchase of new software;

❖ Secondly, the Microsoft Excel program is a convenient tool for further processing of the data obtained during the implementation of the LPZ. This approach makes it possible to significantly reduce the time spent on mathematical calculations and pay more attention to a detailed consideration of the studied physical laws and phenomena;

❖ Thirdly, this software is the most widespread of those installed on home computers. This allows you to use these works as tasks for self-fulfillment in distance learning.

➢ Developed works had to meet the following requirements:

➢ selection, structuring and systematization of educational material (theoretical, reference and normative);

➢ mathematical models describing the physical phenomena under study should provide an opportunity to set at least 10-15 options for tasks;

➢ the presence of a controlling component.

The requirement for a large number of options makes it possible not only to ensure the individual performance of laboratory work by each of the students, but also to conduct a general comparison of all the results obtained by the group and show the effect of various experimental conditions, which in turn allows a better understanding of the physical laws considered in the work. The control component implies the introduction of test tasks, the implementation of which at the beginning of the lesson can help control the readiness of the group for laboratory and practical classes, and in the case of a check after the laboratory work, it will allow you to control the assimilation of the studied material. At the same time, the presence of answer options in all test tasks is not necessary; questions requiring a numerical solution can be entered without answer options, which allows for a more objective assessment of students' knowledge.

The key here is the definition that an ideal gas is made up of molecules. What kind of molecules, round or square, spherical or irregular in shape, is a secondary question. The main ideal gas is a gas consisting of individual molecules. On the other hand, the equations of state of a gas, such as the laws of Charles, Gay-Lussac, Boyle-Mariotte and Clapeyron-Mendeleev, were discovered experimentally long before the introduction of molecular theory into physics. Moreover, it is important to note that in thermodynamics, which originated long before the introduction of the atomic theory of the structure of matter into science and the appearance of the very term "gas molecule", unlike the molecular theory, it is completely indifferent what the gas consists of. Purely historically, scientists imagined gas as an infinitely divisible matter that had no internal structure. Thus, the equations of state of a gas (the Laws of Charles, Boyle and Mariotte, Gay-Lussac and Mendeleev-Claiperon) are thermodynamic equations, and not molecular ones at all. Since, their formulations do not imply a molecular structure, but rather they are carried out for any gas structure [6].

Taking into account that with temperature change the parameters of the van der Waals equation change monotonously and slowly, in order to reveal the desired dependence on them temperature, it is necessary that the "working" temperature range be sufficient large: as a rule, 1500–2500 K. It should be noted that not for all gases, for which the model is built using virial coefficients, the range temperatures at which a gas can be considered van der Waals is so wide. Therefore, in the laboratory work "Isothermal expansion of gases" only inert gases that best illustrate the objectives of the study. Besides, also taking into account the slow change in the temperature dependence of physical gas parameters, the accuracy of registration of gas states should be sufficient high so that changes in the studied parameters remain obvious in comparison with rounding errors of pressure, temperature and gas volume changes.

No thermodynamic parameter can be changed without affecting one or even two other parameters. It happens that a gas of a given mass passes from one state to another, changing only two parameters, leaving the third unchanged. Such a transition is called an isoprocess, and the equation of its regularity is called a gas law. An isoprocess is a process in which the mass of a gas and one of its thermodynamic parameters remain unchanged. The gas law is a quantitative relationship between two thermodynamic parameters of a gas at a fixed value of the third one.

1. Isothermal process - the process of changing the state of a thermodynamic system at a constant temperature. For an ideal gas, the isothermal process is described by the Boyle-Mariotte law.

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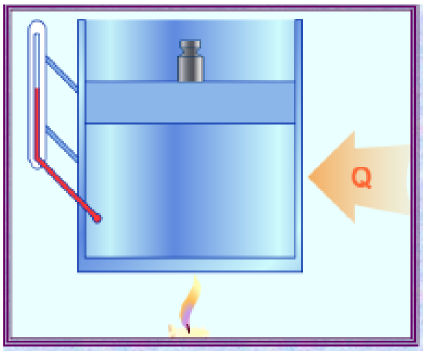
The law was established experimentally before the creation of the molecular kinetic theory of gases by the English physicist Robert Boyle in 1662 and the French abbe Edmond Mariotte, who described similar experiments independently of Boyle in 1676. Boyle-Mariotte law (isothermal process, T=const)

$$m = \text{const},\ T = \text{const} \quad pV = \text{const} \qquad (1)$$

For a gas of a given mass at constant temperature, the product of pressure and volume is constant.

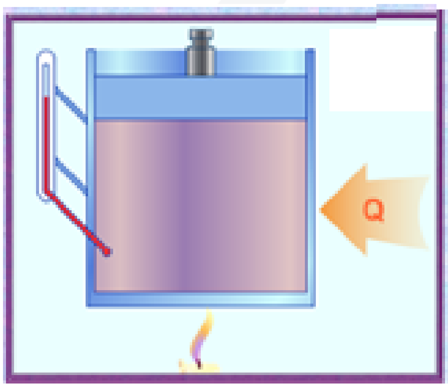


$Q = A'$.

2. Isobaric process - the process of changing the state of a thermodynamic system, proceeding at a constant pressure. Gay-Lussac's law (isobaric process p=const)

$$m = \text{const},\ p = \text{const} \quad \frac{V}{T} = \text{const} \qquad (2)$$

For a gas of a given mass at constant pressure, the ratio of volume to temperature is constant.



$Q = A' + DU$.

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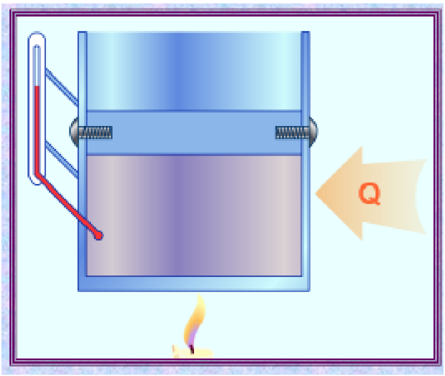
3. Isochoric process - the process of changing the state of a thermodynamic system, occurring at a constant volume.

$$m = const, \ V = const$$

$$\frac{p}{T} = const \qquad (3)$$

For a gas of a given mass at constant volume, the ratio of pressure to temperature is constant.



$$Q = DU.$$

These developments made it possible to conduct laboratory and practical classes in the mode of individual development of educational material, when absolutely all students present at the lesson are involved in the work. Moreover, when using the opportunity at the end of the lesson to summarize the data obtained by all students in the group, it is possible to show broader patterns of the studied laws. Classes conducted in this way showed the advantages of the developed methodology in comparison with the traditional order of conducting classes, when, in the absence of laboratory facilities on the board, the material covered is analyzed, and then problems are solved. Classes, using the developed workshop, are held with great interest and an increase in the quality of assimilation of educational material, which is confirmed by the grades received by students on the basis of laboratory and practical classes. Students get the opportunity to individually achieve their goals. Software mathematical data processing allows paying more attention to physical problems. And the final generalization of the results obtained by the group as a whole allows a deeper understanding of the studied physical laws and processes.

CONCLUSION

Based on the feedback from the students performing the work, the following points should be noted: it is necessary to focus in the future on the development of web applications, since in this case there are no special requirements for the operating system; it is necessary to concentrate on improving the quality of graphics, as modern students are quite sophisticated in matters of virtual reality; the least number of complaints are caused by VLRs written using the JavaScript language. From the point of view of attracting teachers to the development of VLR, the following requirements for development tools can be distinguished: visualization of the development process, ease of writing code, use of a large number of existing functions for solving mathematical and physical problems. Taking into account the experience gained in working remotely, we can conclude that it is necessary to continue efforts to develop VLR in the future, since the availability of our own developments will improve the quality of the educational process for students of various forms of education.

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