The software package includes individual simulation labs executed in the form of graphical applications for desktop computers running various operating systems, as well as in the form of web applications, which are executed in a web browser with support for Web GL technology.

The graphical user interface of each virtual lab includes a minimal number of controls. When the application is launched after loading the data, the lab main menu is displayed on the screen (Fig.1).
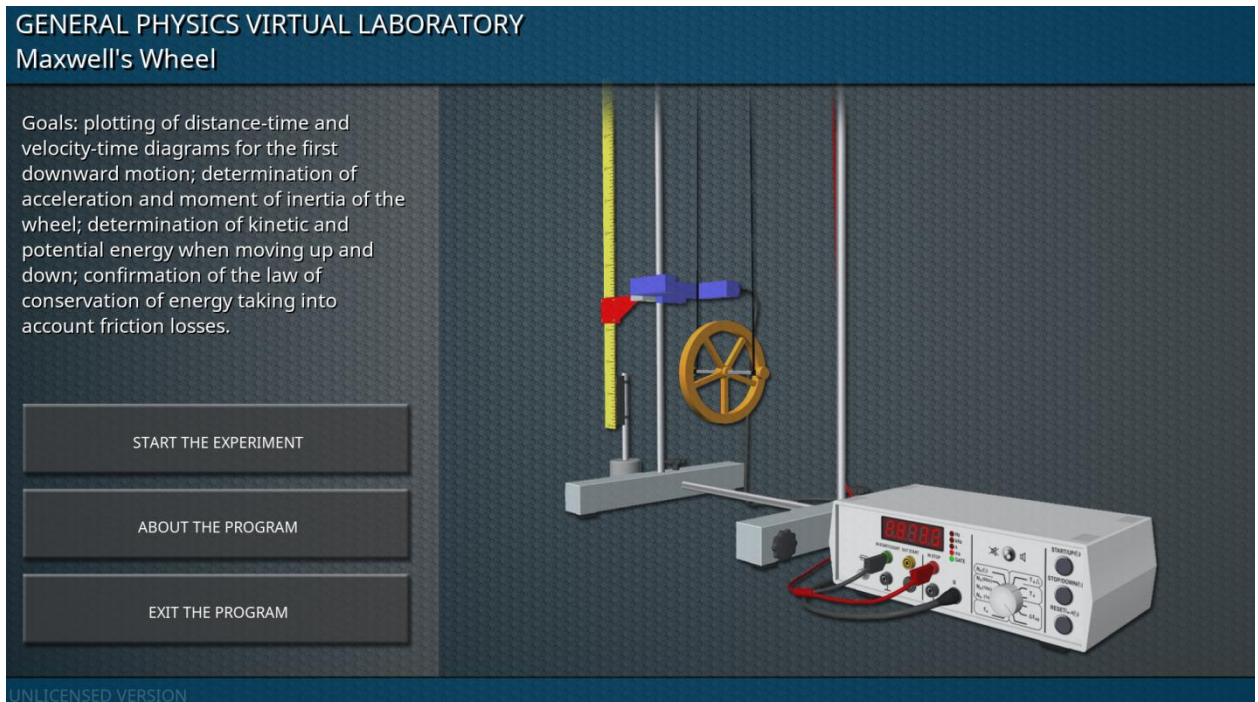

Fig. 1 – Virtual lab main menu

The main part of the main menu displays the appearance of the laboratory equipment. On the left side of the main menu, the name of the laboratory complex, the name of the laboratory work, a short list of the goals of the laboratory work, and also the main buttons of the main menu are given. The «START THE EXPERIMENT» button is intended to start a virtual laboratory work. The «ABOUT THE PROGRAM» button calls up a screen containing basic information about the developer of the software product. The «EXIT THE PROGRAM» button is active only in the desktop version of the application, and is intended to call the application shutdown dialog screen (Fig.2). In the web version, the application is closed by closing the corresponding tab of the web browser.
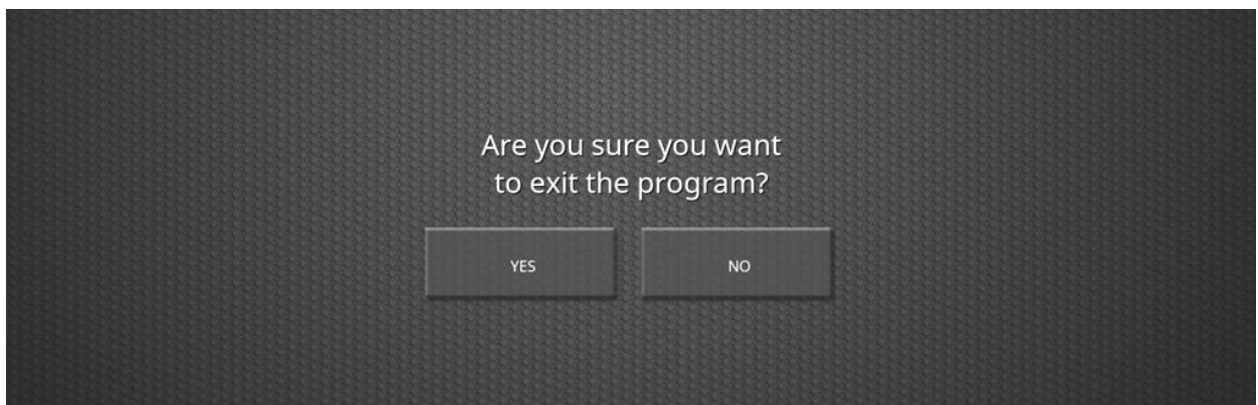

Fig. 2 – Application shutdown dialog screen

When switching from the main menu to the virtual laboratory work, a three-dimensional scene is displayed on the screen with the image of models of laboratory equipment placed in an abstract spatial environment (Fig.3).
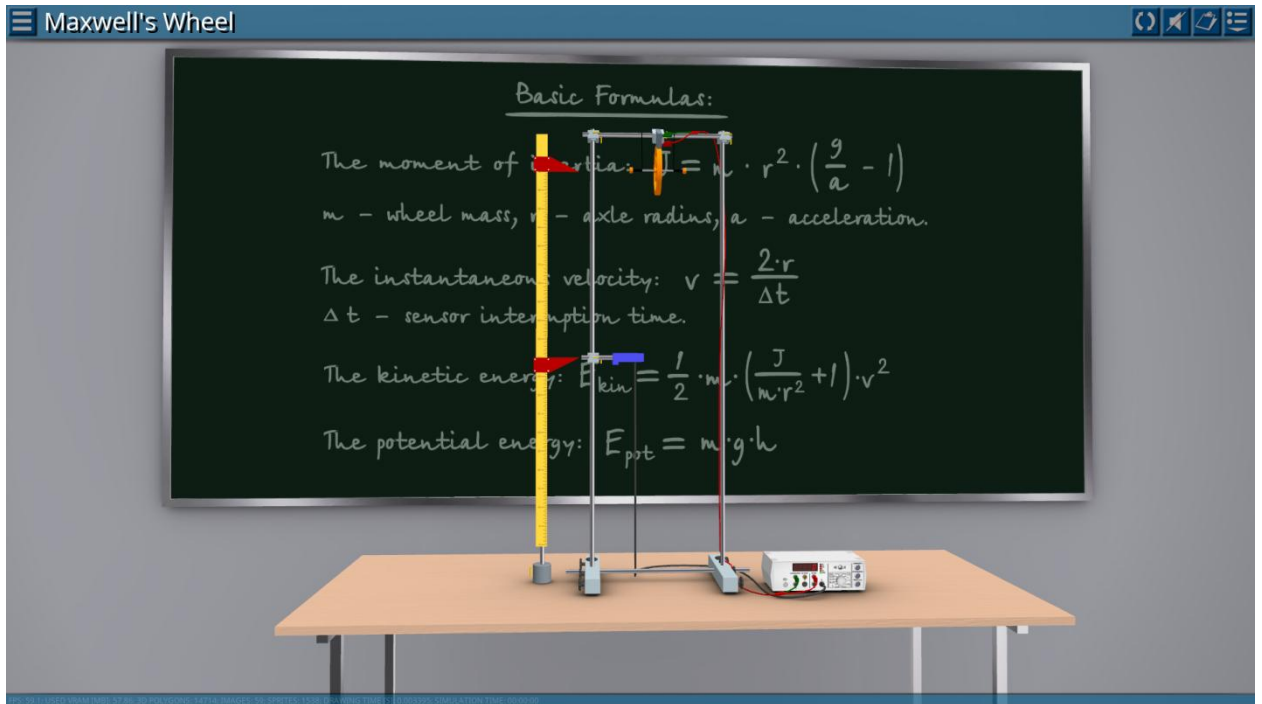

Fig. 3 – Virtual lab 3D scene

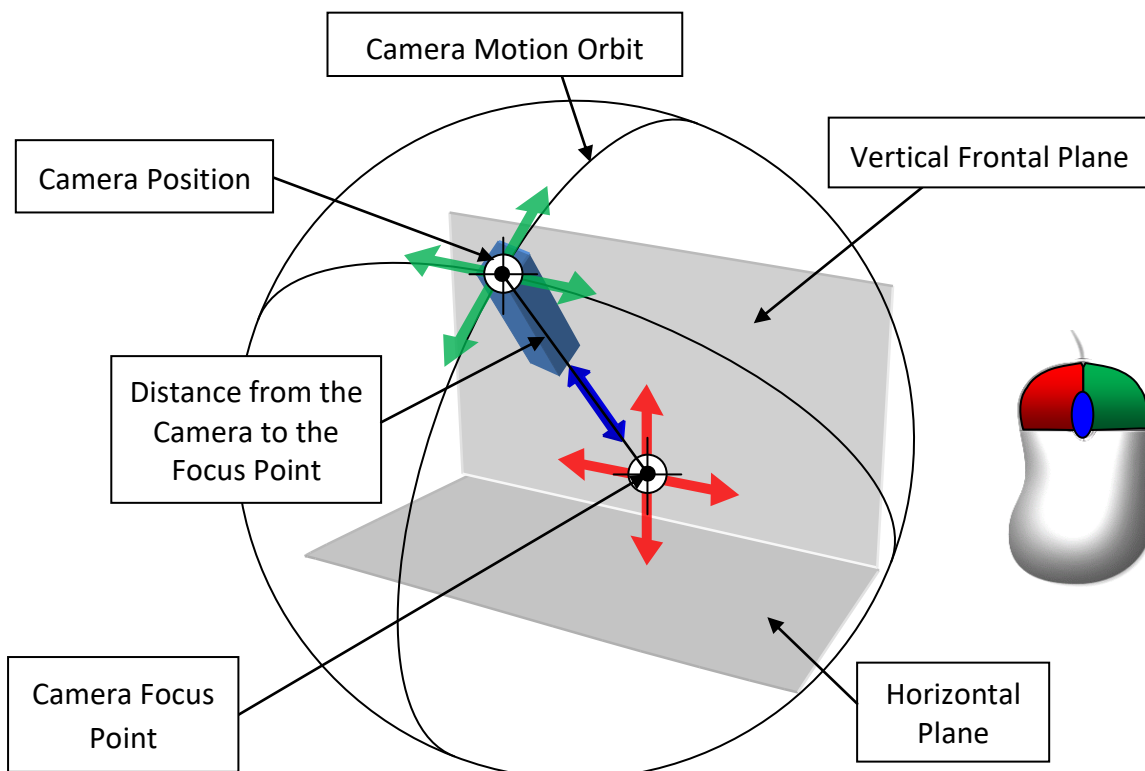The main manipulations with the virtual camera are carried out using a computer mouse (Fig.4).

Fig. 4 – Virtual camera control principle

Pressing and holding the left mouse button with the accompanying movement of the mouse leads to the movement of the camera focus point in the frontal plane of space. Pressing and holding the right mouse button with the associated mouse movement rotates the camera relative to the focus point. The rotation angles (azimuth and elevation) of the camera are limited by the dimensions of the model space. Changing the distance of the camera is carried out by rotating the scroll wheel in the forward and reverse directions.

Thus, all three-dimensional models of laboratory equipment are fully viewed by the user from various angles.

The main element of the interface of the virtual laboratory work is the upper panel, in the left part of which there is a button for returning to the main menu, as well as the name of the laboratory work being performed (Fig.5).

Fig. 5 – Button to return to the main menu of the virtual lab

In the right part of the top panel there is a group of functional buttons (Fig. 6): «RESET LABORATORY SETUP», «TURN ON/OFF SOUND», «EXPORT DATA», «SHOW/HIDE CONTROL PANEL» (from left to right, respectively).
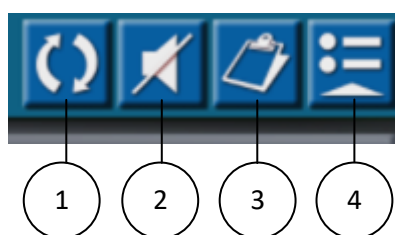

Fig. 6 – Virtual Lab Screen Function Buttons

The reset button (1) of the lab setup is intended to return the virtual lab to its original state. Using the button (2), the user can disable/enable the sound. Pressing the button (3) generates a report with the results of the measurements performed in the CSV-table format. In the desktop version of the application, the report is automatically opened by a program associated with this file type (for example, Microsoft Excel). In the web version, the report file is downloaded using the standard web browser file download function. Data is written to the report as the experiment runs. At the same time, in most laboratory work, the event of recording the measurement result into report is accompanied by a characteristic sound signal. Button (4) is designed to show or hide the main panel of laboratory parameters. Each lab has its own set of parameters displayed on the panel (Fig. 7).

All virtual labs are built on the same principle. Based on this, two types of virtual experiments can be distinguished: 1) with a countable course of time; 2) models that are not tied to the passage of time. For the first type of experiments in the upper part of the parameter panel there are always buttons for controlling the simulation process: «START», «PAUSE» and «STOP». The following are parameters with variable numeric/text values and parameters with non-variable values. If the virtual laboratory work is accompanied by a diagram, on the parameter panel there is a button for displaying the diagram "SHOW DIAGRAM" on the screen (Figure 8).
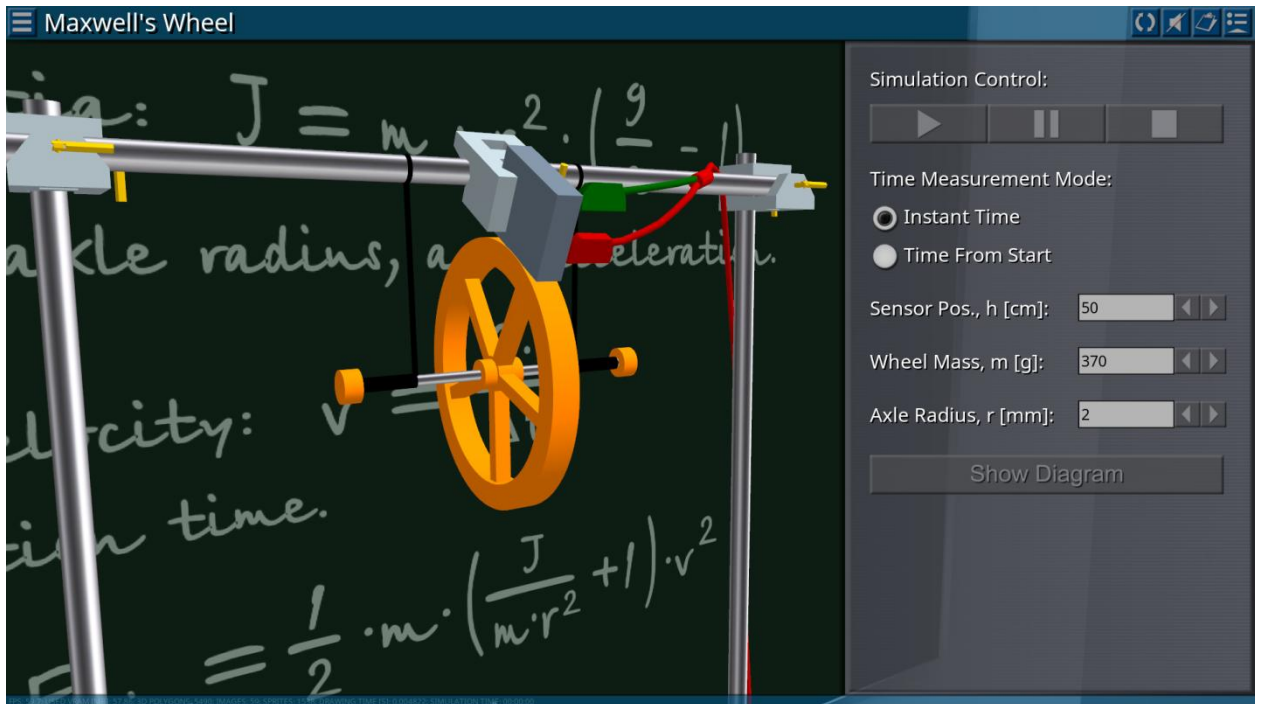
Fig. 7 – An example of displaying the options bar on the right side of the screen

The screen for working with a diagram allows you to select areas on the coordinate plane, as well as change the scales of the coordinate axes. To close the diagram screen, press the «SHOW DIAGRAM» button again. When the simulation is stopped, the data in the diagram is automatically deleted.
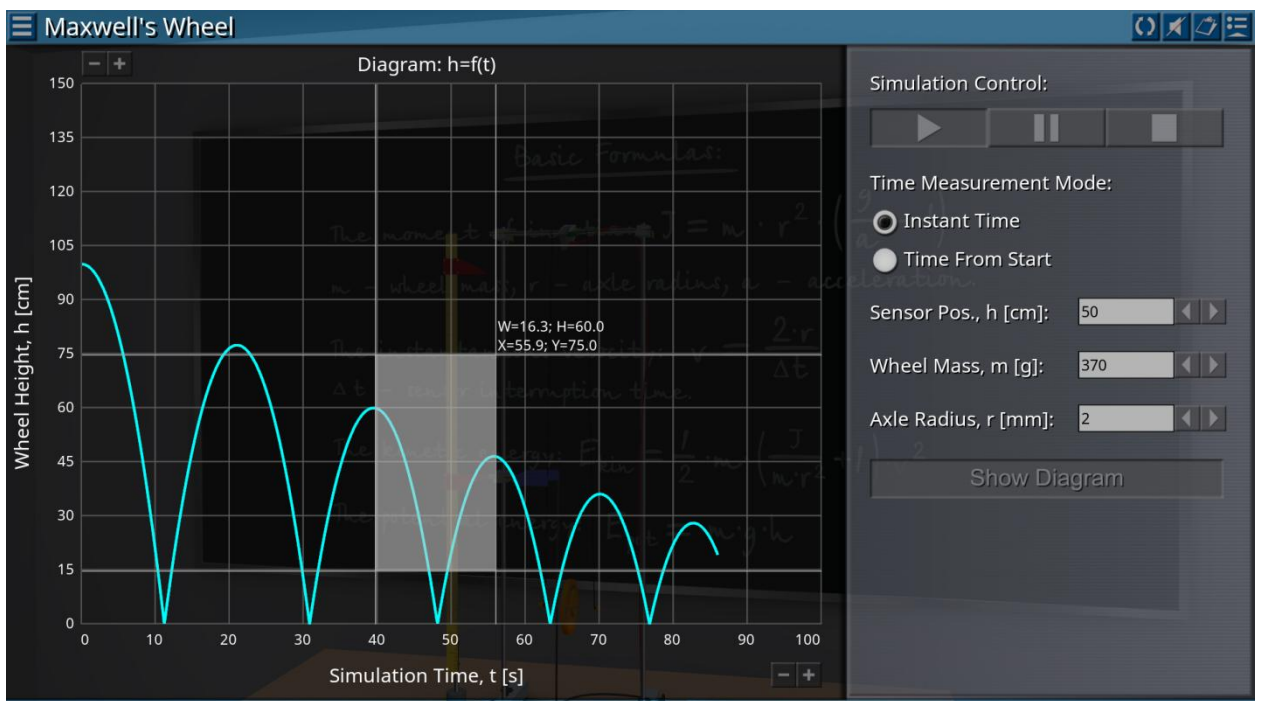

Fig. 8 – Diagram display example

At the bottom of the virtual lab screen, information about the resources used by the application is displayed.