



Virtual laboratory



SCIENCE

Atwood Machine

User
manual 



Table of Contents

1 System requirements	4
2 Interface of the application	5
3 Camera Control	6
4 Main menu	7
4.1 Instructions	7
4.2 Interactive tips	8
4.3 Virtual keyboard.....	9
4.4 Fullscreen Mode	10
4.5 Scene Menu	10
4.5.1 Saving a scene	10
4.5.2 Saving a copy of the scene	11
4.5.3 Creating a new scene	12
4.6 Viewing and loading user scenes	12
5 Description of objects	13
5.1 Atwood Machine system	13
5.1.1 Atwood Machine installation.....	13
5.1.2 Experiment Control panel.....	14
5.1.3 Installation operating procedure	15
5.1.3.1 Preparation for the system launch	15
5.1.3.2 System launch.....	15
5.1.3.3 Returning the system to its original state.....	16
5.2 Overloads.....	16
5.3 Laboratory journal.....	17
5.3.1 Opening the journal	17
5.3.2 Viewing the list of studies	18
5.3.3 Creating a new study	19

Terms and Definitions

The following general terms are used in the User Guide:

Term	Definition
Virtual Laboratory	Application Virtual Laboratory "Science", section "Atwood machine".
Scene	A virtual three-dimensional space within which the user can interact with the Virtual Laboratory objects. The concept of "scene" also includes the data of the current research (positions of objects, their parameters, etc.)
Process simulation	The process of interaction between objects in a scene modeled in the Virtual Laboratory.
Camera	A scene tool with which the user observes everything that happens in the Virtual Laboratory.
Click	To make a click: — when using a mouse, move the mouse pointer to the object, press and release the left mouse button without moving the pointer; — when using a touchscreen, press the object with a finger and release it without moving the finger along the screen.
Toggle Button	A button that changes its state from inactive to active and vice versa after being pressed. The state is retained until the next interaction.

1 System requirements

The minimum system requirements for running the application "Virtual Laboratory "Physics", section "Atwood machine" are:

- **Processor:** Intel Ivy Bridge series / AMD Bulldozer series.
- **RAM:** 4 GB.
- Graphics Card:
 - Integrated: Intel HD Graphics 5000 / Intel Iris;
 - Discrete: GeForce 400 series or newer / Radeon HD 7000 series.
- **Screen Resolution:** 1920x1080 / 1920x1200 (4K and Retina displays require a more powerful graphics card for comfortable operation).
- **Supported Browsers:** Chrome, Yandex.Browser, Opera 44+, Firefox 51+, Edge 79+, Safari 15+.
- **Supported Operating Systems:** Microsoft Windows 7 (x64 versions) with WebGL 2.0 driver support, MacOS X "Snow Leopard" 10.6 with WebGL 2.0 driver support, Linux or Debian with WebGL 2.0 driver support.

2 Interface of the application

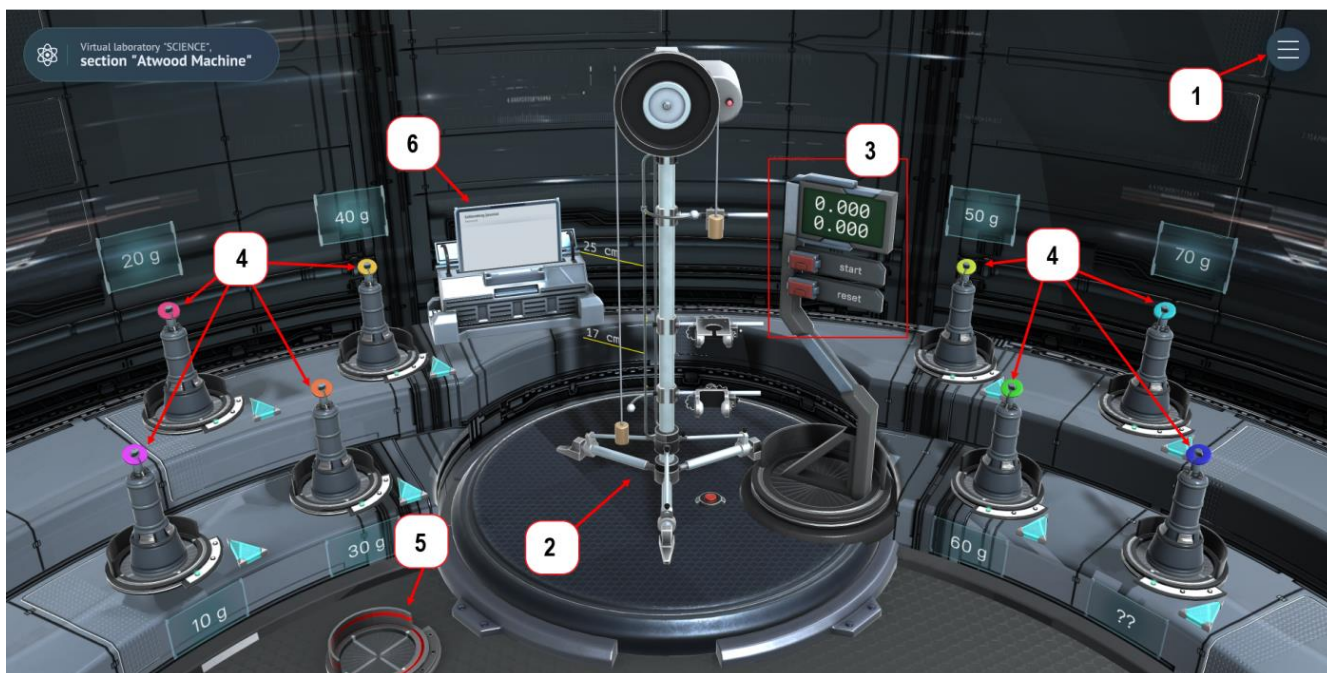


Figure 1 – Interface of the Virtual Laboratory

The virtual laboratory is a virtual three-dimensional environment for conducting laboratory studies of uniformly accelerated motion of a system of bodies.

The Virtual Laboratory interface (Figure 1) includes the following elements:

- 1) **Main Menu** (see [4 Main menu](#)).
- 2) Virtual installation "**Atwood Machine**" (hereinafter referred to as the Atwood Machine) is a three-dimensional model that imitates the structure and external properties of a real device and repeats the logic of its behavior (see [5.1.1 Atwood Machine installation](#)).
- 3) **Experiment Control panel** contains a screen for displaying stopwatch data, buttons for starting the installation and resetting data (see [5.1.2 Experiment Control panel](#)).
- 4) **Overloads** of different masses for conducting experiments (see [5.2 Overloads](#)).
- 5) **Slot for removing the overloads** (see [5.2 Overloads](#)).
- 6) **Laboratory Journal** (see [5.3 Laboratory journal](#)).

3 Camera Control

The camera is controlled using the mouse or your fingers (when using a touch screen).

While the application is loading, the camera is in default position — aimed at the center of the table. (Figure 2).

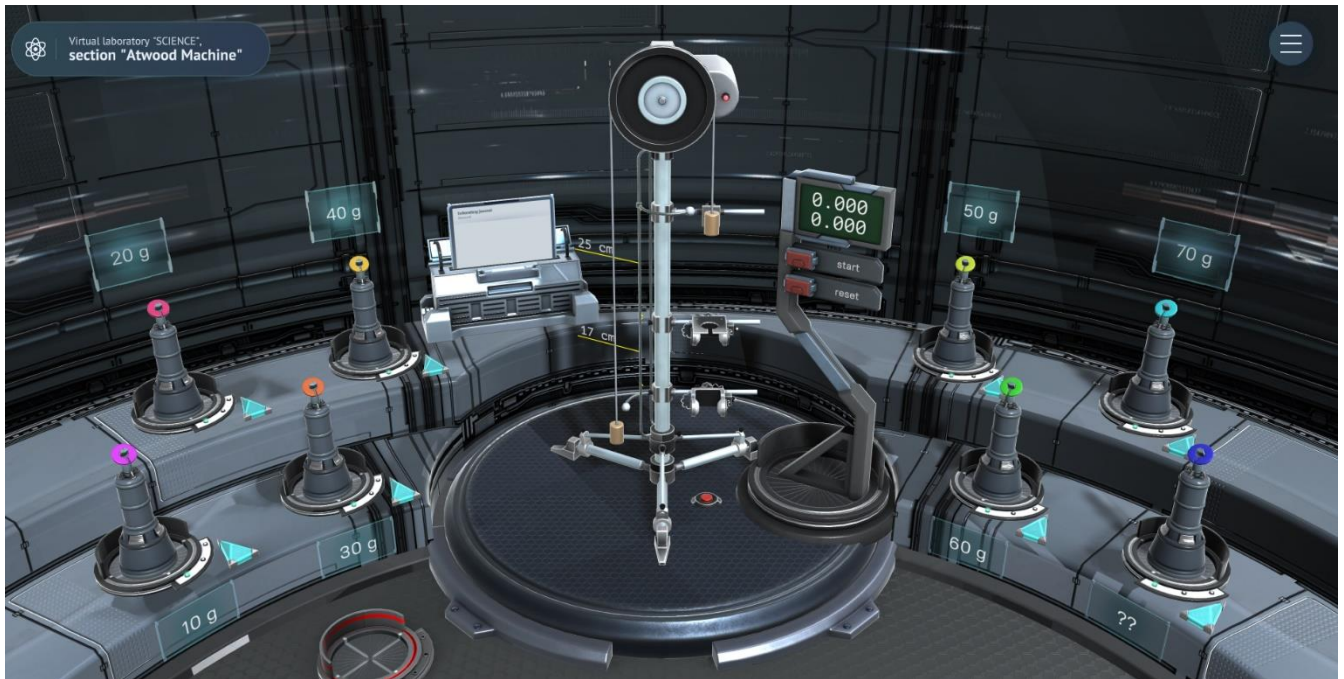


Figure 2 – Default camera position

To zoom in/out, rotate the mouse wheel. When using the touch screen, touch the screen with two fingers, then spread them apart or press them together. Click on the part of the installation to zoom in as close as possible. To return the camera to its default position, click anywhere in the scene around the installation.

To move the camera, hold down the right mouse button anywhere in the scene, drag the pointer in the desired direction and release the button.

4 Main menu

To open the **Main menu**, press the button  in the upper right corner of the application (1 in Figure 1). The main menu consists of the following elements (Figure 3):

- 1) A set of functional buttons:
 - Instruction button  (see [4.1 Instructions](#));
 - Tips Mode Activation button  (see [4.2 Interactive tips](#));
 - Virtual Keyboard Activation button  (see [4.3 Virtual keyboard](#));
 - Fullscreen Mode button  (see [4.4 Fullscreen Mode](#))
- 2) Username display field.
- 3) Scene Menu (see [4.5 Scene Menu](#)).

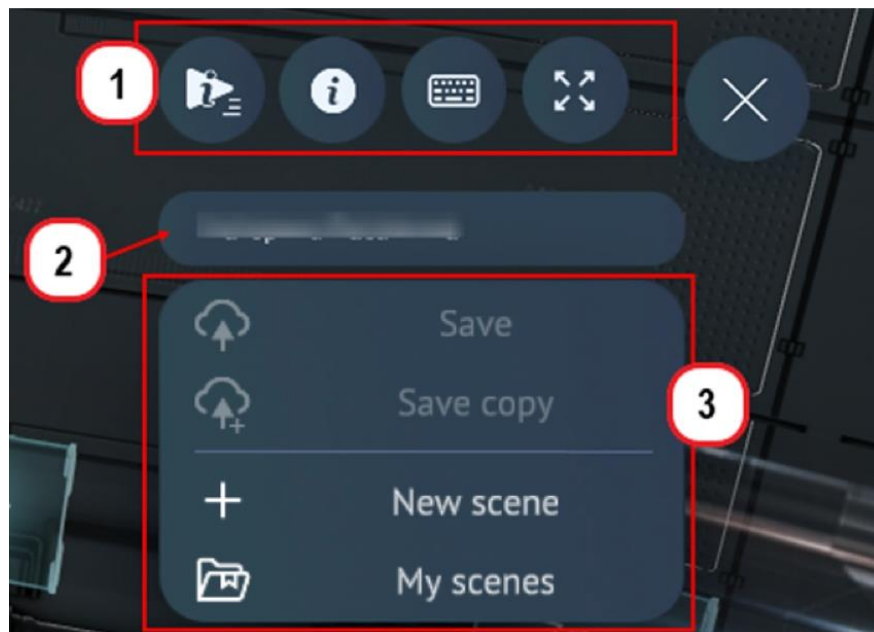


Figure 3 – Main menu

To close the **Main menu**, press the button  or click anywhere in the scene outside of the menu.

4.1 Instructions

There are User manual you can read and two video instructions you can watch:

- "Introduction Video": watch to understand how to work with objects
- "Saving and loading": watch to understand how to save created scenes and load saved scenes

To select a video to watch, click the **Instructions** toggle-button  in the **Main menu** (Figure 3). Menu for selecting video instructions will open. (Figure 4).

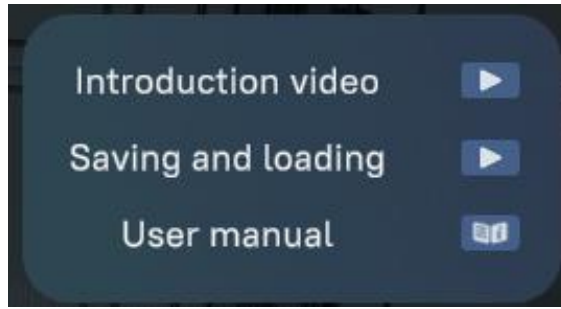


Figure 4 – Menu for selecting video instructions

Click on the video title to start watching. The video will play on the screen over the scene. Control playback using the built-in player (Figure 5).



Figure 5 – Player control elements

To close the playback screen, click the Close button  in the upper right corner of the screen. To close the video instruction selection menu, press the  button.

4.2 Interactive tips

To switch to interactive tips mode, use the **Tips Mode** toggle-button  in the **Main menu** (Figure 3). Tip-dots will appear next to the objects in the scene, and a description of the installation will open on the left side of the screen (Figure 6).

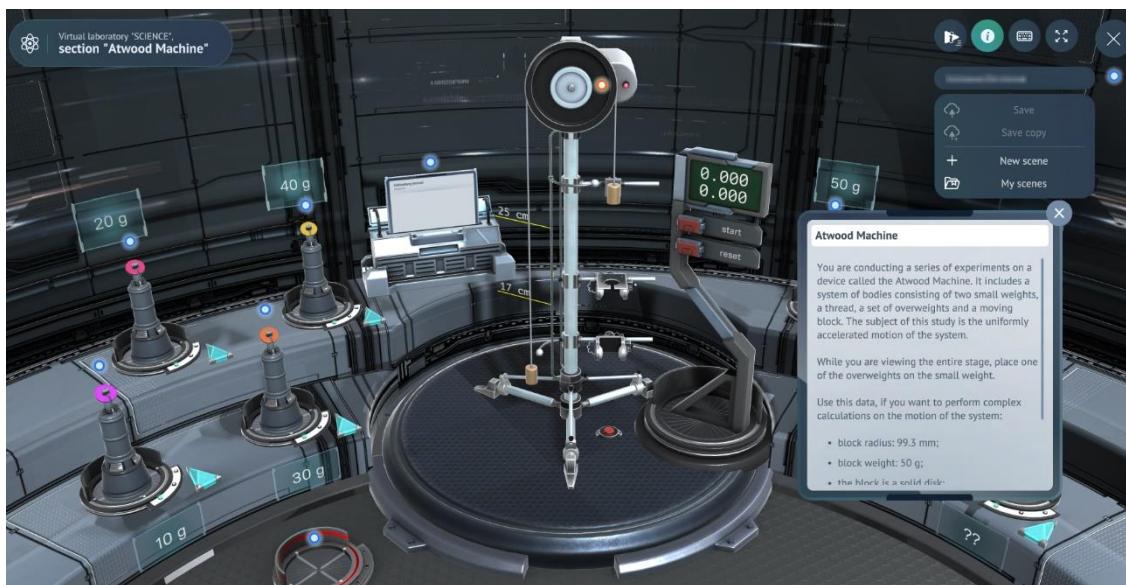


Figure 6 – Tips Mode

To open a tip about the desired object, click on the dot next to it. To close the tip panel, click on the cross in the upper right corner of the panel or click on the tip-dot again.

Tip-dots change outline color depending on how the user views them (Figure 7):



Figure 7 – Color options for the dot outlines

- 1) A point with an orange outline  – the tip panel is open on the screen (as in Figure 7).
- 2) If several objects have the same tips, and one of such tips is currently open, then the tip points of other objects with the same tip will have a double outline: grey and orange dashed .
- 3) A point with a grey outline  – the user previously viewed and closed the tip.
- 4) A point with a blue outline  – the user has not yet viewed the tip.

To exit the **Tips Mode**, press the  button in the **Main menu**.

4.3 Virtual keyboard

To be able to use the virtual keyboard, use the toggle-button  in the **Main menu** (Figure 3). In this mode, a virtual keyboard appears on the screen after clicking on the text fields in the scene card (Figure 8).



Figure 8 – Virtual keyboard

The virtual keyboard has two layouts: Latin and Symbolic. The layout is changed using the  button on the virtual keyboard.

To exit the **Virtual Keyboard Mode**, press the  button in the **Main menu**.

4.4 Fullscreen Mode

To enable full screen mode, press the **Fullscreen Mode** button  in the **Main menu** (Figure 3). The application will expand to full screen, hiding the browser frame and the OS taskbar. To exit fullscreen mode, press the  button or the **Esc** button on your keyboard.

4.5 Scene Menu

While working in the Virtual Laboratory, you can:

- save the current scene (see [4.5.1 Saving a scene](#));
- save a copy of the current scene (see [4.5.2 Saving a copy of the scene](#));
- create a new scene (see [4.5.3 Creating a new scene](#));
- open the **My Scenes** library (see [4.6 Viewing and loading user scenes](#));

To go to one of the actions, select the desired menu item for working with scenes (Figure 9).

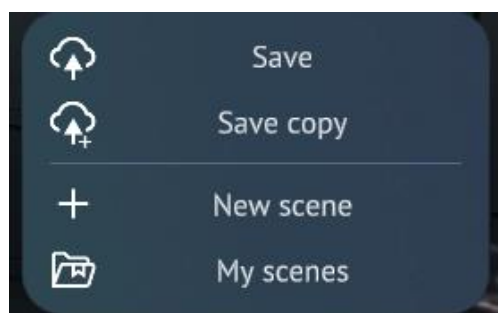


Figure 9 – Scene Menu

To close the **Scene Menu** (and the **Main menu**), press the  button or click anywhere in the scene outside the menu.

4.5.1 Saving a scene

To save the created scene in the **My Scenes** library, select **Save** in the **Scene Menu** (Figure 9). The scene state and lab log entries will be saved.

If the scene has already been saved, the application will overwrite the contents of the scene file. If the scene is being saved for the first time, the scene saving form will open (Figure 10).

Figure 10 – Scene saving form

Enter the name of the scene to be saved (no more than 36 characters) and its description (no more than 1000 characters) in the appropriate fields of the form and click the button .

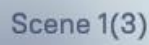
You can use the virtual keyboard if necessary. To do so, use the  button left of the saving form. This button duplicates the  button in the **Main Menu** (see [4.3 Virtual keyboard](#)): if the Mail Menu had the Virtual Keyboard Mode enabled , then the button next to the scene saving form will also be in the active state — .

If you want to cancel the saving of the scene, press the button .

4.5.2 Saving a copy of the scene

To save a copy of the scene in the **My Scenes** library, select **Save Copy** in the **Scene Menu** (Figure 9). This will open the form for saving a copy of the scene, which is similar to the scene saving form (Figure 10).

If the scene is being saved for the first time, you must fill in the Scene Name (no more than 36 characters) and Scene Description (no more than 1000 characters) fields.

If the scene has already been saved, the previously saved scene name with the copy number in brackets will be displayed in the Scene Name field — . The scene name and copy number can be adjusted or left unchanged.

Press the  button to save a copy of the scene.

After you have saved a copy, you will continue to work with it, and the copy of the scene you worked with before will remain in the state of its last save.

If you do not need to save the scene copy, press the button .

4.5.3 Creating a new scene

To create a new scene, select **New Scene** in the **Scene Menu** (Figure 9). If there are unsaved data, a window with a warning about possible data loss will open (Figure 11).

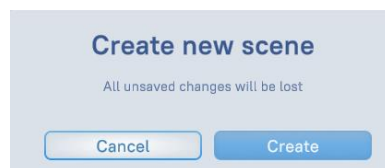


Figure 11 – Create New Scene window

To avoid losing current data, click the button  and continue working with the scene. If you do not need to save the data, click , after which all unsaved data will be lost and a new empty scene will open.

4.6 Viewing and loading user scenes

To view a list of scenes, select **My Scenes** in the **Scene Menu** (Figure 9). The **My Scenes** library page will open (Figure 12).

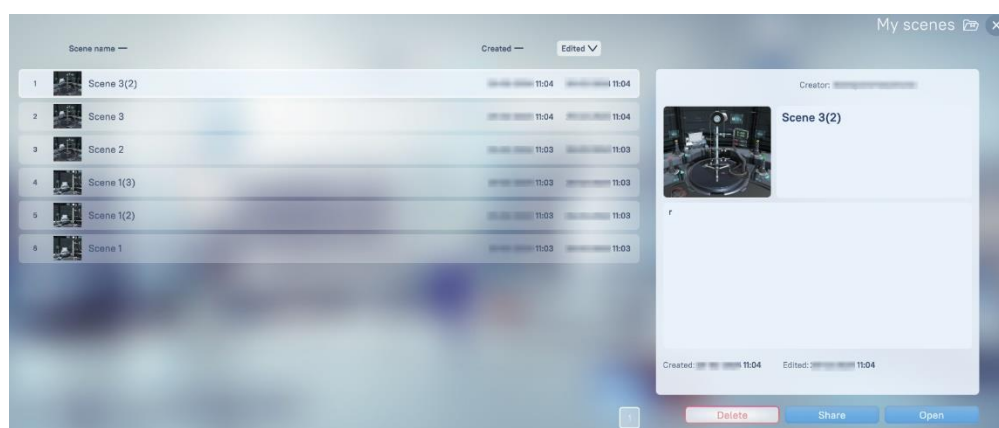


Figure 12 –My Scenes library

On the left side of the screen, a list of all saved scenes will be displayed. You can sort the data by scene name, creation date, and modification date. To sort, click on the name of the corresponding table column (Name, Created or Modified). The "-" icon next to the name will change to a check mark,

indicating the sorting direction .

If the list of scenes does not fit on one screen, it will be split into pages. Navigation through the pages is done using a series of buttons with page numbers, located to the right under the table.

The information about the selected scene is in the scene card to the right of the table. If necessary, you can open, delete, or share the selected scene using the buttons located under the scene card.

5 Description of objects

5.1 Atwood Machine system

5.1.1 Atwood Machine installation

The Atwood Machine virtual installation (hereinafter referred to as the Atwood machine) is a three-dimensional model that imitates the structure and external properties of a real device and repeats the logic of its behavior. During research, you can change the load on the system using a set of overloads (see [5.2 Overloads](#)), measure the time of movement of the bodies and record the research results in a laboratory journal (see [5.3 Laboratory journal](#)).

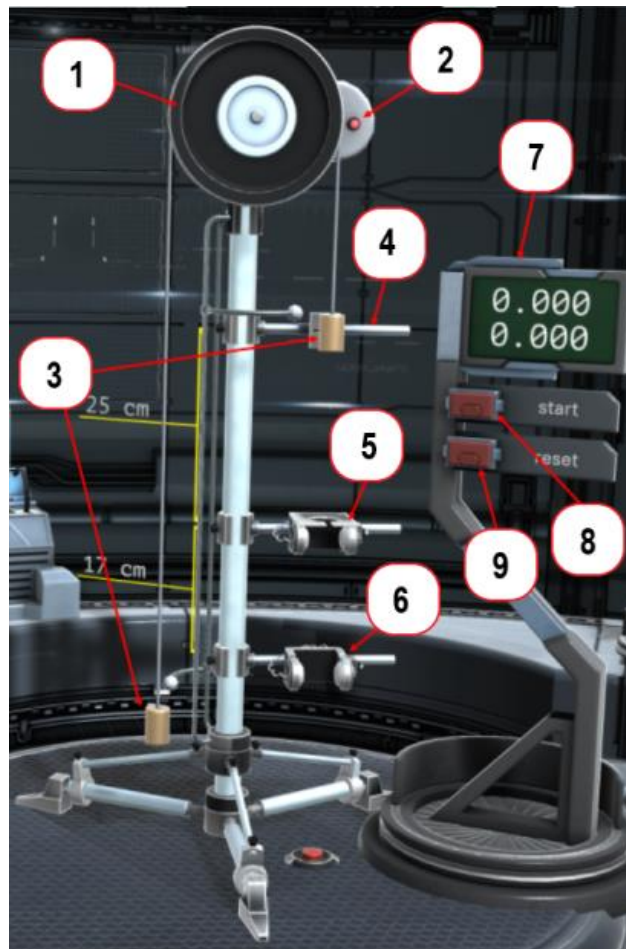


Figure 13 –Atwood Machine system

The Atwood Machine virtual installation consists of the following elements (Figure 13):

- 1) Stand with a fixed block (the block is a solid disk, the radius of the block is 99.3 mm; the mass of the block is 50 g);
- 2) Electric block brake with color indicator;
- 3) A system of two weights connected by a thread (the mass of each weight is 150 g);
- 4) A rail with a mark for the start of the movement, attached to the stand using a clamp;
- 5) Photo sensor with a plate with a hole, attached to the stand using a clamp, removes overloads from the weight;
- 6) Photo sensor without plate, attached to the stand using a clamp.

If the masses of the weights are equal, then the system is in a state of equilibrium regardless of the position of the weights. To change the mass of the weights and set the system in motion, use overloads (see 5.2 Overloads). During the study, the overload on the right weight is removed by a plate with a hole installed on the photosensor (5 in Figure 13).

Virtual marks located along the device's stand (Figure 14) show:

- 1) The distance between the rail with the mark for the start of movement and the photosensor with the plate;
- 2) The distance between the photosensor with a plate and the photosensor without a plate.

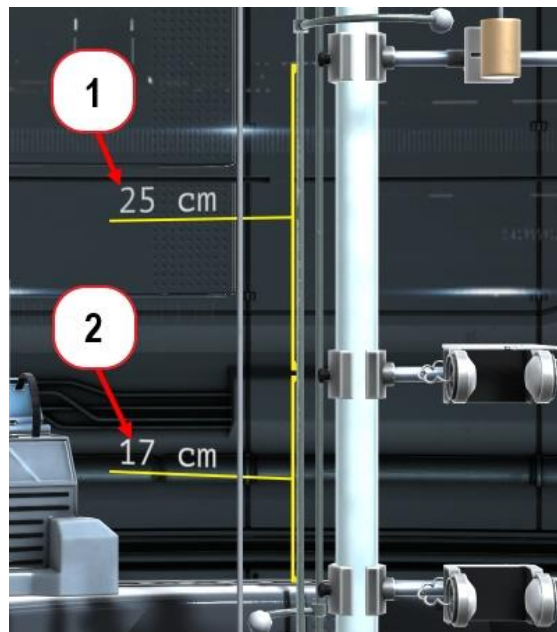


Figure 14 – Distances between the rail and the photosensors

To change the distances between the elements on the stand, left-click the clamp or the rail that secures the element to the stand. Drag it up or down to the desired position. In this case, the distances between virtual marks will be automatically recalculated. The clamp movement step is 1 cm.

5.1.2 Experiment Control panel

The **Experiment Control** panel consists of the following elements (Figure 13):

- 7) Stopwatch with two timers;
- 8) Start button;
- 9) Reset button.

The timers on the stopwatch count down the time of movement of the right weight in two segments:

- 1) Upper timer — from the rail with the start of the movement mark (4 in Figure 13) to the photosensor with the plate (5),
- 2) Lower timer — from a photosensor with a plate (5 in Figure 13) to a photosensor without a plate (6).

When oscillating, the bottom timer may start several times. The timing will stop only when the weight passes through the photosensor without a plate.

To start the movement of the installation, press the **Start** button (8 in Figure 13). For more information about the operating procedure of the installation, see [5.1.3 Installation operating procedure](#).

To return the installation to its original state and reset the received data, press the **Reset** button (9 in Figure 13).

5.1.3 Installation operating procedure

5.1.3.1 Preparation for the system launch

The initial state of the Atwood machine is considered to be the state of the system in which (see Figure 13):

- the right weight is suspended at the level of the horizontal mark (3);
- the indicator on the electric brake of the unit (2) lights up red — the brake is locked;
- the values on the stopwatch screen (7) are at zero.

To prepare the system for the launching, install the clamps of the rail with the start of the movement mark (4) and the photo sensors (5) and (6) at the required distance from each other and place overloads of the required weight on both weights or on one of them. If necessary, move the camera closer to the installation by rotating the mouse wheel.

5.1.3.2 System launch

To start the system, press the **Start** button on the **Experiment Control** panel (8 in Figure 13).

Atwood machine will start working:

- The Start button indicator lights up green.
- The electric brake (2) is released and its indicator lights up green.
- The weights (3) begin to move on a stationary block.
- The upper timer on the stopwatch (7) starts the countdown.
- The right weight passes through a plate with a hole located above the photosensor (5). The overload is removed from the weight and remains on the plate.
- The right weight passes through the photosensor (5). The top timer on the stopwatch stops the countdown. The lower timer starts.
- The right weight passes through the photosensor (6). The lower timer stops counting.
- The weight is lowered onto a rubber-lined platform.
- The system stops.



If you start the system without overloads or with overloads of the same mass on both weights, then movement will not begin, since the system will be in equilibrium.

5.1.3.3 Returning the system to its original state

To return the system to its original state, press the **Reset** button on the control panel (9 in Figure 13).

The installation will return to its original state:

- The time in the stopwatch display is reset to 0.000.
- The electric brake (2) rotates the stationary block in the opposite direction. The brake indicator lights up yellow.
- The right weight passes through the photosensors (6) and (5).
- The right weight passes through a plate with a hole placed above the photosensor (5). The overload is put on the weight and continues to move with it.
- The right weight stops opposite the start mark (4).
- The electric brake indicator lights up red — the brake is locked.
- The system stops.

5.2 Overloads

Overloads are additional weights that are installed on the weights. In the Virtual Laboratory, overloads weighing from 10 g to 70 g in increments of 10 g are available (1 in Figure 15). The overload weight is indicated next to its holder. One of the overloads (2 in Figure 15) has a random mass from the same range.



Figure 15 – Overloads

To get started with the installation, place the overloads on one or each of the weights. To do this, hold down the left mouse button on the overload with the desired mass, drag it onto the weight and release it. After placing the overload on the weight, the green indicator (1 in Figure 16) lights up next to the weight, and a sign appears next to the block indicating the weight of the placed overload (2). Only one

overload can be placed on each weight. If an overload is already placed on the weight, then when you try to place a second overload on it, the indicator lights up red (Figure 17).

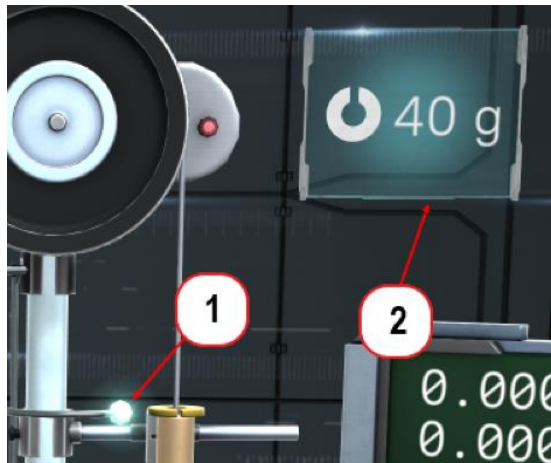


Figure 16 – The overload is placed on the weight

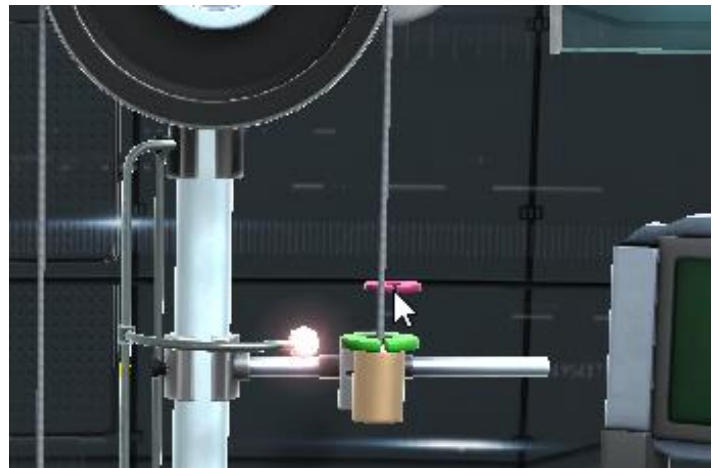


Figure 17 – Incorrect placement of the overload

To delete an overload, hold it with the left mouse button, drag it to the delete slot (6 in Figure 1) and release (Figure 18).



Figure 18 – Deleting an overload

5.3 Laboratory journal

The laboratory journal (6 in Figure 1) is used to record the conditions of the experiments and their intermediate results. While working with the journal, you can:

- open the journal (see [5.3.1 Opening the journal](#));
- view the list of studies and delete unnecessary ones (see [5.3.2 Viewing the list of studies](#));
- create a new study (see [5.3.3 Creating a new study](#)).

5.3.1 Opening the journal

To open a journal, click on the journal or on its stand (Figure 19).

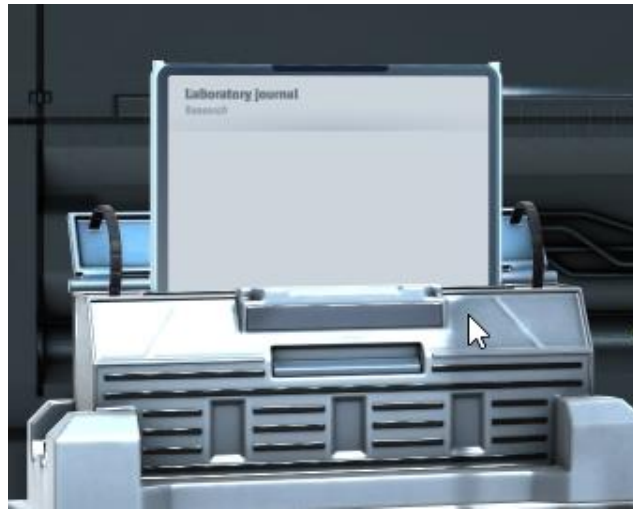


Figure 19 – Opening the journal

The journal will open on the left side of the screen (Figure 20). If journal entries have already been made in the current scene, they will be displayed in the open journal. If there were no entries, an empty journal will open.



Figure 20 – Laboratory journal

To collapse an open journal, click on its stand or hold down the journal with the left mouse button and drag it off the screen border on the left.

5.3.2 Viewing the list of studies

The list of studies is a set of cards, each of which contains data about the study: number, time and date of creation, name of the study, masses of overloads used and the number of records about the results of the study (Figure 21).

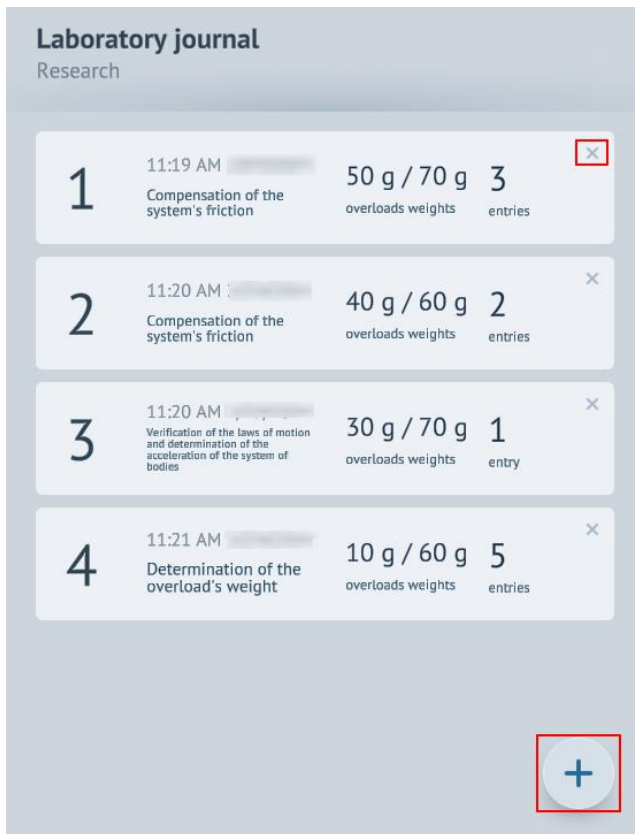


Figure 21 – The list of studies

5.3.3 Creating a new study

To create a new study, press the  button in the lower right corner of the journal (Figure 21). A panel with research options will open (Figure 22). To select a study type, click the appropriate button.

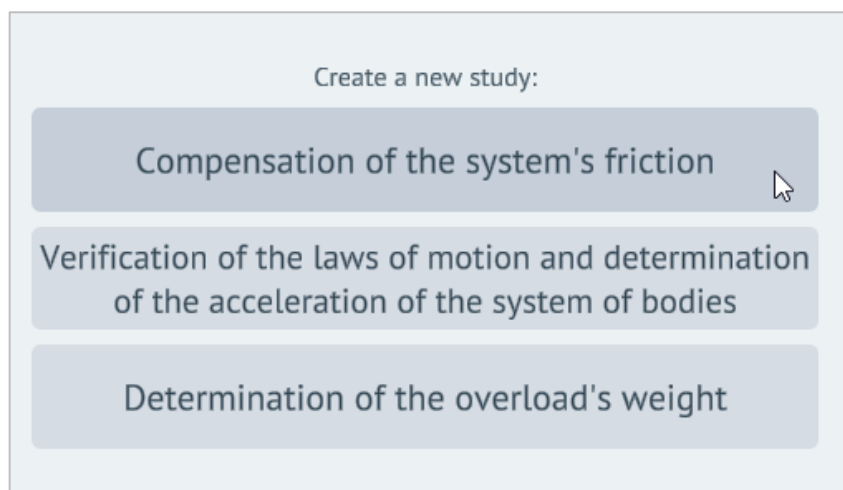


Figure 22 – Choosing the type of the study

After this, the entry page will open. The appearance of the recording page depends on the type of study selected.

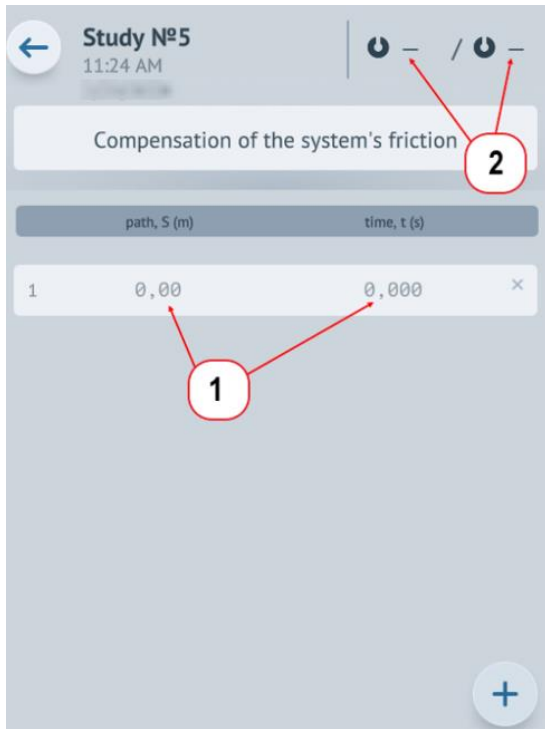


Figure 23 – Page for entries

To enter data, left-click on the desired input field (1 in Figure 23) and enter the values using the keyboard of your device or the virtual keyboard (see [4.3 Virtual keyboard](#)).

Enter overload mass values used in the study in Fields (2).

To add a line for more entries, press the button  in the lower right corner of the page.

To delete a line of entries, press the  button in the upper right corner of the line.

To return to the list of studies in the journal, press the  button in the upper left corner of the page.