



Virtual laboratory



PHYSICS

Molecular Physics and Thermodynamics

User
manual



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Terms and definitions

Term	Definition
Virtual lab	Application Virtual laboratory “Physics”, section “Molecular Physics and Thermodynamics”
Camera	Scene tool, which allows the user to observe everything going on in the Virtual Lab
Toggle button	A type of button that changes its state from inactive to active and vice versa when the button is pressed. The state is saved until the next press
Pressing an object/button	The action to take: – when using the mouse is to move the mouse pointer to the object/button and press the <u>left mouse button</u>; – when using the touch screen is to press an object/button with your finger
Workspace	A part of the scene, where the user can interact with the Virtual Lab objects available to him/her
Desktop	A part of the scene intended for placing objects and interacting with them
Process simulation	The process of interaction of objects in the scene modeled in the Virtual Lab
Scene	A virtual three-dimensional space, where the user can interact with Virtual Lab objects. The definition of “scene” also includes data from the current study (positions of objects, their parameters, etc.)

1 System Requirements

Minimum system requirements for the application **Virtual laboratory “Physics”, section “Molecular Physics and Thermodynamics”** are as follows:

- **Processor:** Intel Ivy Bridge series / AMD Bulldozer series and newer.
- **RAM:** 4GB or more.
- **Graphics card:**
 - integrated: Intel HD Graphics 5000 / Intel Iris and later;
 - discrete: GeForce 400 series or newer / Radeon HD 7000 series or newer.
- **Screen resolution:** 1920x1080 / 1920x1200 and larger (4K and Retina screens require a higher power 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) or higher with WebGL 2.0 driver support, MacOS X Snow Leopard 10.6 or higher with WebGL 2.0 driver support, Linux or Debian with WebGL 2.0 driver support.

2 Application interface

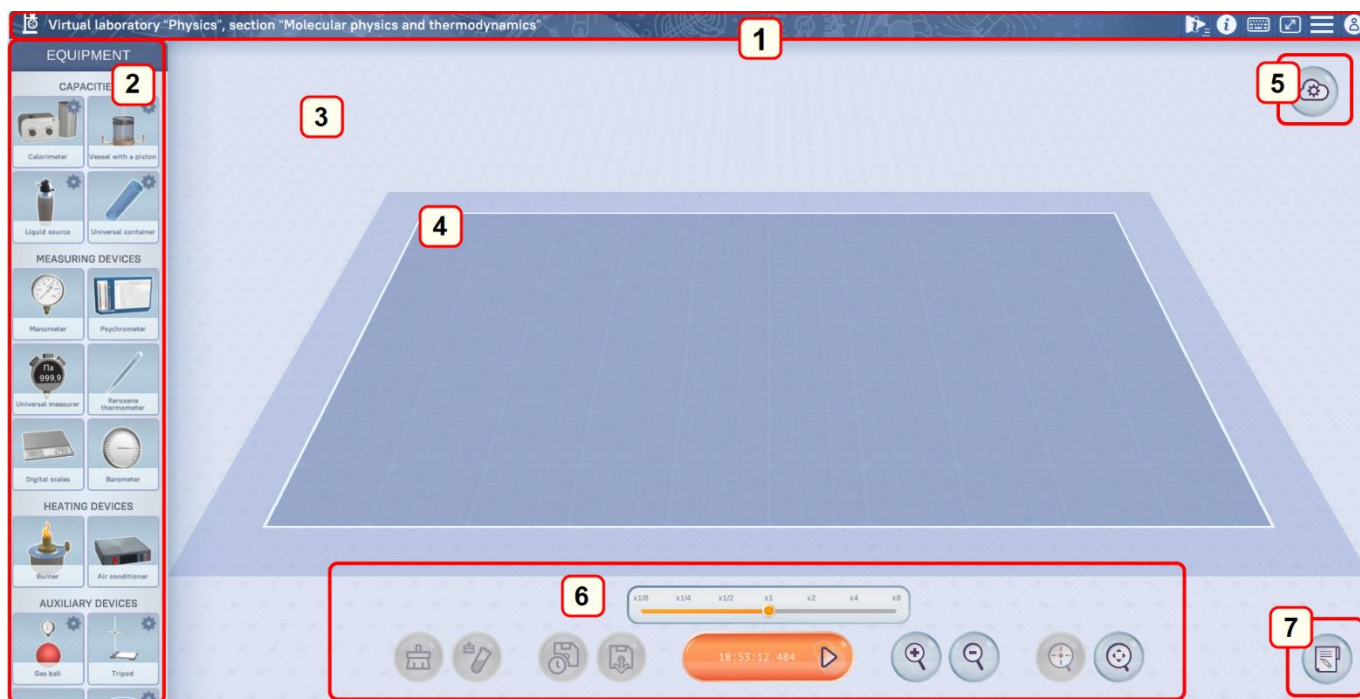


Figure 1 – Virtual Lab interface

The Virtual Lab interface is shown in Figure 1 and includes the following elements:

- **The Application Header panel** (1) contains the Virtual Lab logo and name (left) and a set of functional buttons (right) (see section 3 “Application Header panel”).
- **The Equipment panel** (2) contains cards of all objects that can be used in the scene (see section 8 “Equipment panel”).
- **Workspace** (3) is a part of the scene, where you can create items from the list of available equipment, interact with them, navigate with the camera, and control the simulation of interactions.
- **Desktop** (4) is a part of the scene intended for placing objects and interacting with them
- **Environment button**  (5) (see section 6 “Setting the environment”).
- **The control panel** (6) contains scene and process simulation controls (see section 7 “Control panel”).
- **Scene card button**  (7) (see section 4 “Scene card”).

3 Application Header panel

The **Application Header** panel contains the logo and the name of the Virtual Lab on the left, and a set of functional buttons on the right (Figure 2):

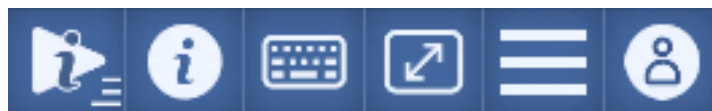


Figure 2 – Function buttons of the Application Header panel

- button to call up video tutorials  (see 3.1 “Video Instruction”);
- button to enable tips mode  (see 3.2 “Tips mode”);
- button to enable/disable the virtual keyboard mode  (see 3.3 “Virtual Keyboard”);
- button to enable/disable fullscreen mode  (see 3.4 “Fullscreen mode”);
- button to call up the scene menu  (see 3.5 “Scene menu”);
- button to call up the user menu  (see 3.6 “User Profile”).

3.1 Video Instruction

With this menu you can:

- watch the video tutorial on working with the stage and equipment — **Introduction video**;
- watch the video tutorial to learn how to save created scenes and load saved scenes — **Saving and loading**;
- read how to use the application — **User manual**.

To select educational material, click the **Video Instruction** toggle button  in the **Application Header** panel. A menu for selecting educational material will open (Figure 3).

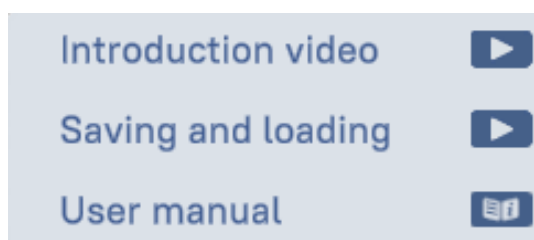


Figure 3 – Educational material selection menu

To start watching the desired video, click on its title. The video will play on the screen on top of the scene. Control playback with the built-in player (Figure 4).

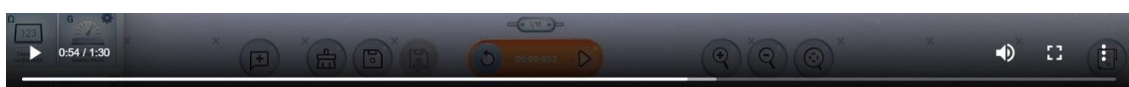


Figure 4 – Player controls

To close the playback screen, click the **Close** button  in the upper right corner of the screen.

3.2 Tips mode

To switch to the interactive tips mode, click the **Tips** toggle button  in the **Application Header** panel. In the scene, tips points will appear next to the objects (Figure 5).



Figure 5 – Tips mode

To view the tip, click on such a point (Figure 5). To close the tip panel, click the cross in the upper right corner of the panel or click the tip point again.

Tips points change the outline color depending on how the user views the tip (Figure 6):

- 1) Blue outline point  (1) — the user has not yet viewed the tip point.
- 2) Gray outline point  (2) — the user has previously viewed and closed the tip.
- 3) Orange outline point  (3) — the tip point is open on the screen (as in Figure 5).
- 4) If several objects have the same tips, and one of such tips is currently open, the tips points of other objects with the same tip will have a double outline: gray and orange dashed  (4).



Figure 6 – Different outline color of tips points

Besides, the Virtual Lab has three hidden icons with tips: **Moving objects**, **Deleting objects**, **Moving around the scene** (Figure 7). They are only visible in tips mode.



Figure 7 – Hidden icons with tips

To exit tips mode, click button  on the **Application Header** panel.

3.3 Virtual Keyboard

To switch to the virtual keyboard mode, press toggle button  in the **Application Header** panel. In this mode, the virtual keyboard will appear automatically when you type in any text field (Figure 8).



Figure 8 – Virtual keyboard

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

To exit the virtual keyboard mode, click button  on the **Application Header** panel.

3.4 Fullscreen mode

To enable full screen mode, click **Fullscreen** button  in the **Application Header** panel. The application will be expanded to fullscreen; all other elements of your device's desktop will be hidden. To exit fullscreen mode, press button  or the **Esc** key on the keyboard again.

3.5 Scene menu

Working in the Virtual Lab, you can:

- save the current scene (see 3.5.1 “Saving a scene”);
- save a copy of the current scene (see 3.5.2 “Saving a copy of the scene”);
- create a new scene (see 3.5.3 “Creating a new scene”);
- open the **My scenes** library (see 3.5.4 “Viewing and loading user scenes”);
- share a link to the current scene (see 3.5.5 “Saving a link to a scene”).

To switch to one of the actions, click button  on the **Application Header** panel and select the required item of the scene menu (Figure 9).

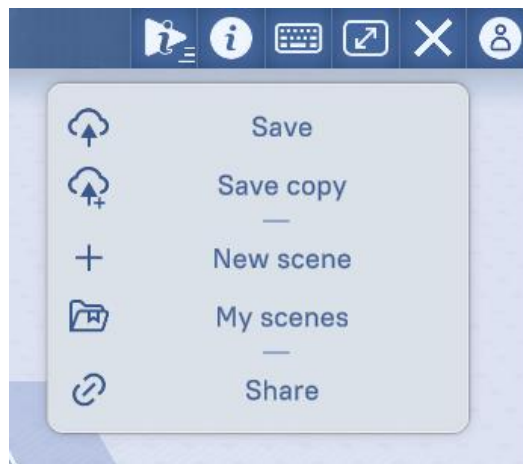


Figure 9 – Scene menu

To close the scene menu, click  or anywhere in the scene outside the menu.

3.5.1 Saving a scene

To save the created scene in the **My scenes** library, select the **Save** item in the scene menu (Figure 9).

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

Figure 10 – Save Scene form

Enter the name of the scene to be saved (max. 36 characters), its description (max. 1000 characters) in the corresponding fields of the form and click button .

If the **Scene name** and **Scene description** fields were previously filled in the scene card (see 4 “Scene card”), these values will be displayed when saving the scene.

If necessary, you can call up the virtual keyboard with button  to the left of the save form. This button duplicates button  in the application header (see 3.3 “Virtual Keyboard”): if the virtual keyboard mode has been enabled in the application header , the button next to the Scene Save form will also be in the active state — .

To cancel saving the scene, press button .

3.5.2 Saving a copy of the scene

To save a copy of the scene in the **My scenes** library, select the **Save copy** item in the scene menu (Figure 9). The form of saving a copy of the scene will be opened, just like the form of saving a scene (Figure 10).

If the scene is saved for the first time, the **Scene name** (max. 36 characters) and **Scene description** (max. 1000 characters) fields must be filled in.

If the scene has been previously saved, the **Scene Name** field displays the previously saved scene name with the copy number in brackets, e.g., **Сцена 1(3)**. You can adjust the scene name and copy number or leave it unchanged.

If the **Scene name** and **Scene description** fields were previously filled in the scene card (see 4 “Scene card”), these values will be displayed when saving a copy of the scene.

Press button  to save a copy of the scene.

Once you save a copy, you will continue to work in it. The scene you were working with before saving the copy will remain in the state of its last save.

To cancel saving a copy of the scene, press button .

3.5.3 Creating a new scene

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

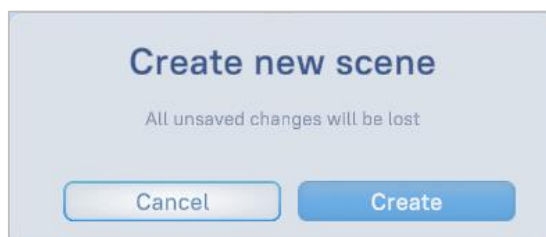


Figure 11 – “Creating a new scene” window

To avoid losing the current data, press button  and save the scene. If you do not want to save the data, click , then all unsaved data will be lost, and a new empty scene will open.

3.5.4 Viewing and loading user scenes

To view a list of your saved scenes, select **My scenes** from the scene menu (Figure 9). The **My scenes** library page will open (Figure 12).

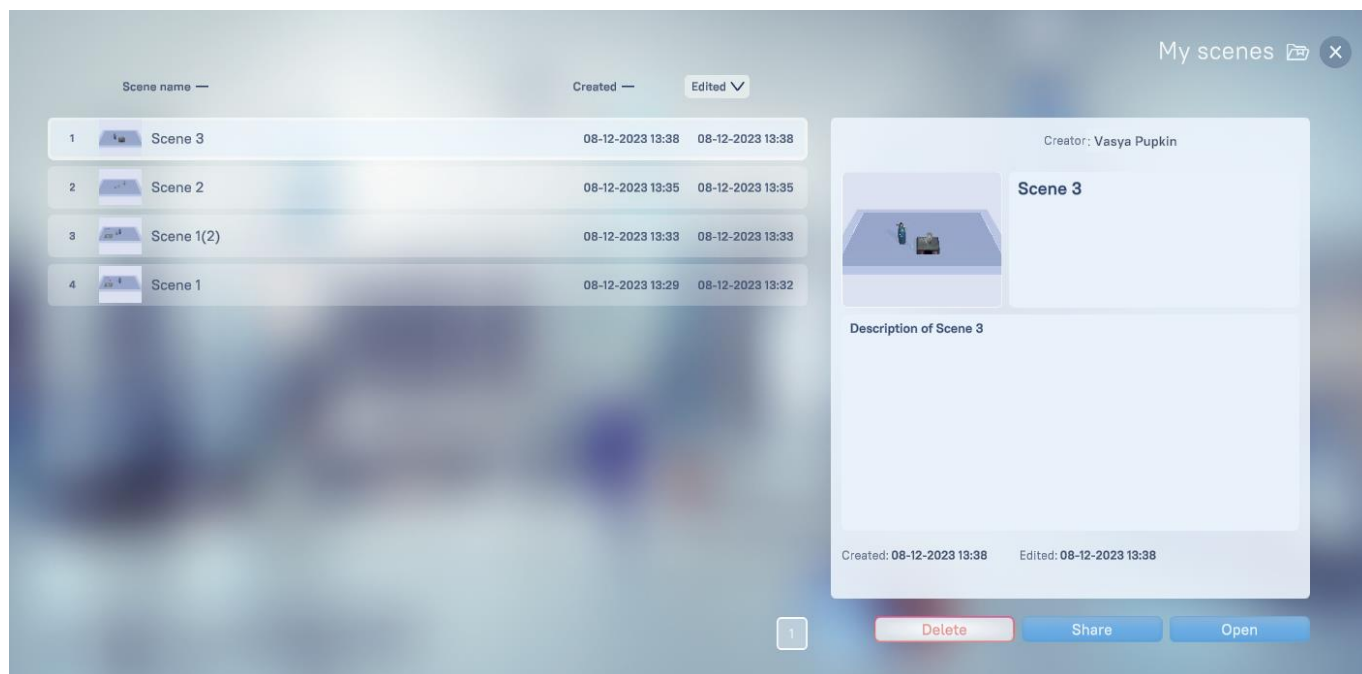


Figure 12 – My scenes library

On the left side of the screen, in the table, a list of all saved scenes will be displayed. The list can be sorted by name, creation date, and modification date. To sort, click on the name of the corresponding table column (**Scene name**, **Created**, or **Edited**). The icon  next to the name will change to a check

mark indicating the sort direction .

If the list of scenes does not fit on one screen, it will be paginated. Page navigation is accomplished by a series of buttons with page numbers, located to the right below the table.

The card of the scene selected in the list is displayed to the right of the table. Use the buttons below the card to open, delete, or share a link to the selected scene.

3.5.5 Saving a link to a scene

To share a link to the current scene, select the **Share** item in the scene menu (Figure 9). The link will be copied to the clipboard, and the scene will be saved at the same time. If you have never saved this scene before, the Save Scene form will open (Figure 10). You can save or send the link from the clipboard to someone.

3.6 User Profile

When you press the **Profile** button  on the **Application Header** panel, the user login is displayed and the user menu opens (Figure 13).

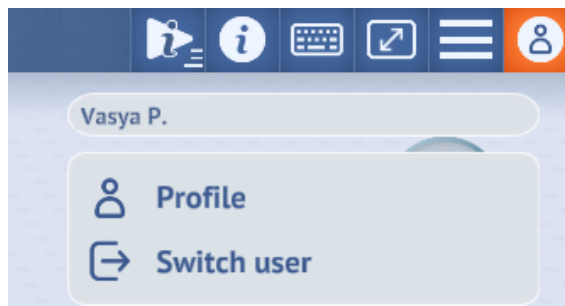


Figure 13 – User Profile

Select the **Profile** menu item to access your profile details. The data will open in a new browser tab.

If you select **Switch user**, two buttons will be displayed below the menu: click  to change the current account, or click  to continue using the current account.

To close the menu, press button  or anywhere in the application window outside the menu.

4 Scene card

The scene card (Figure 14) allows you to fill in and view the information about the scene that you will need when saving the scene.

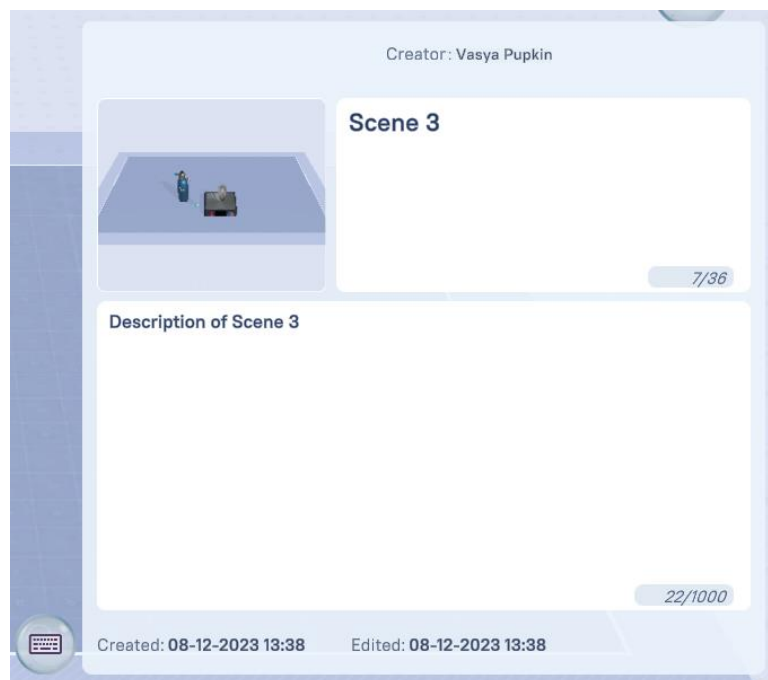


Figure 14 – Scene card

The scene card opens:

- by clicking the **Scene card** button  in the lower right corner of the application window (Figure 1);
- when saving a scene or its copy, see 3.5.1 “Saving a scene” and 3.5.2 “Saving a copy of the scene”);
- when you select a scene in the **My scenes** library (see 3.5.4 “Viewing and loading user scenes”).

The **Scene name** and **Scene description** card fields will be filled in if:

- you have already filled in a scene card;
- you have already saved a scene or a copy of a scene;
- you opened a scene with a filled card via a link from another user;
- you opened a public scene with the card filled in.

In other cases, the **Scene name** and **Scene description** fields of the card will be empty (Figure 14).

The information in the card can be edited and deleted. When filling in or editing the **Scene name** and **Scene description** fields, you can use your device's keyboard or virtual keyboard. For details on how to use the virtual keyboard, see 3.3 “Virtual Keyboard” and 3.5.1 “Saving a scene”.

To close the scene card, click the **Scene card** button again or anywhere in the application window outside the card.

5 Camera

The camera is a scene tool with which you can observe everything that happens in the Virtual Lab.

The camera has two operating modes: standard mode (Figure 15) and focus mode on the selected object (Figure 16).



Figure 15 – Standard camera mode

To switch the camera to focus mode, select the instrument on the desktop (click on it — the instrument will have a white outline) and press button  on the bottom panel.



Figure 16 – Camera focus mode

In standard camera operation mode:

- To move the desktop relative to the camera, at a free point in the workspace (outside the instruments), hold the pointer with the left mouse button (or your finger if using the touchscreen) and pull in the desired direction.
- To move the desktop relative to the camera, at any point in the workspace, hold the pointer with the middle mouse button and drag in the desired direction. At the same time, the interaction with the instruments is ignored.
- To zoom in/out on the desktop, rotate the mouse wheel, and when using the touch screen, tap the screen with two fingers and spread them apart or bring them together.

In camera focus mode:

- To move the desktop relative to the camera, at any point in the workspace, hold the pointer with the middle mouse button and drag in the desired direction. At the same time, the interaction with the instruments is ignored.
- To zoom in/out on the desktop, rotate the mouse wheel, and when using the touch screen, tap the screen with two fingers and spread them apart or bring them together.
- To focus the camera on another instrument, click on that instrument.
- To exit focus mode, click on a free point in the workspace or on a selected instrument.
- To move the instrument left or right across the desktop, click on the instrument with the left mouse button (or with your finger if using the touchscreen) and drag the instrument left or right. At the same time, you cannot move the instrument toward or away from the camera.

6 Setting the environment

Press toggle button  to set the environment. The Environment Settings panel will open (Figure 17). The panel allows you to set the temperature, relative humidity, and pressure (in kPa and mmHg).

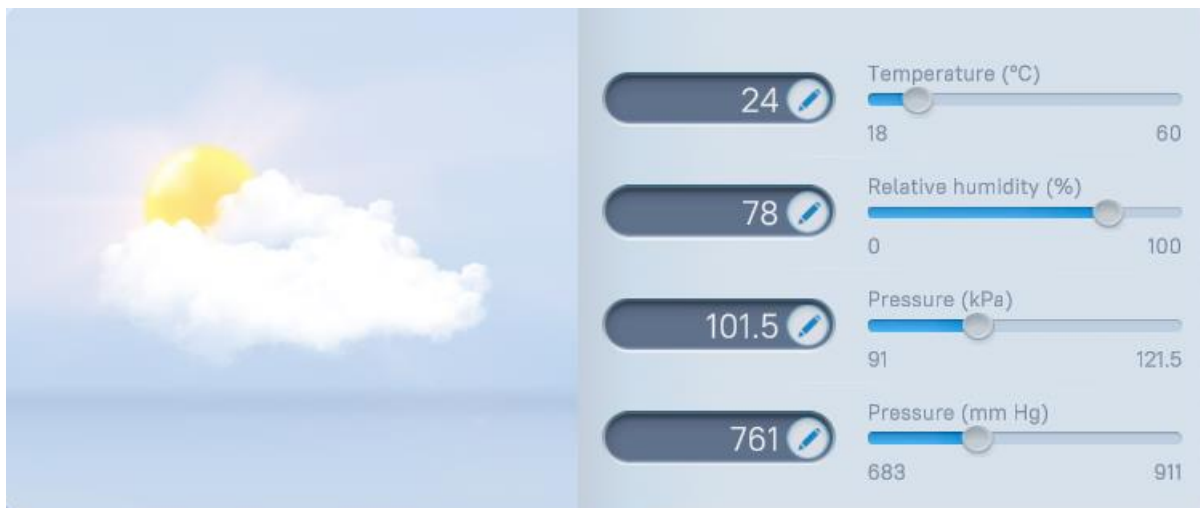


Figure 17 – Environment Settings panel

The environment settings are applied after the panel is closed. To close the panel, click in any area of the screen outside the panel.



In the Virtual Lab, **Relative Humidity** is only used for the environment; the humidity in the containers is not simulated. Therefore, the instruments measuring this index (universal meter and psychrometer) interact only with the environment.

7 Control panel

The control panel contains controls for Virtual Lab and experiment speed (Figure 18).

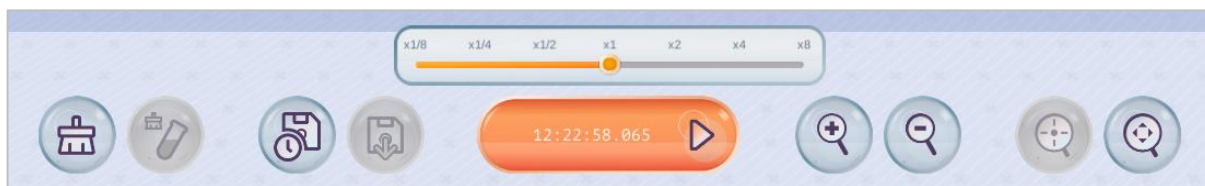


Figure 18 – Control panel

7.1 Stage control buttons

7.1.1 Clear scene button

The **Clear scene** button  is available if at least one instrument is placed on the desktop. If you press the button, the confirmation window opens (Figure 19).

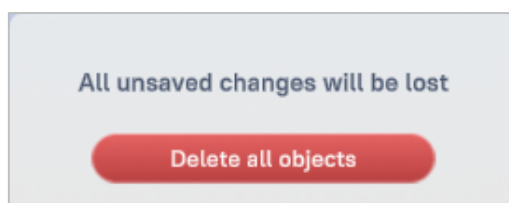


Figure 19 – Scene clearing confirmation window

Click the **Delete all objects** button to clear the scene. To cancel the deletion of all objects, click anywhere on the screen outside the window.

7.1.2 Clear instruments button

The **Clear instruments** button  is only available when the simulation is on and if there are containers filled with fluid or gas on the desktop. If you press the button, the confirmation window opens (Figure 20).

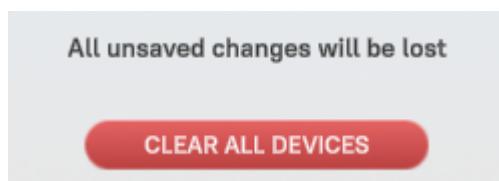


Figure 20 – Instrument clearing confirmation screen

Click the **Clear all containers** button to remove the fluid or gas contained in the containers placed in the scene (except fluid sources), or click anywhere on the screen to cancel the action.

7.1.3 Save point button

The save point is the fixed state of the scene. To create a save point, click the **Save point** button .

The application will save:

- the location and settings of objects;
- the contents of the objects and the state of the substances inside;
- time on the timer;
- environmental parameters.

The application can store only one scene state. Pressing the button again saves the current state instead of the previous state.

Button  is available if at least one object is placed on the desktop.

7.1.4 Return to save point button

The **Return to save point** button  is not available until a save point is created using the **Save point** button . Press button  to return to the last saved scene state. At the same time, the object is deselected.

7.2 Process simulation controls

The following **assumptions** are provided for the simulation:

- Heat transfer within the containers is instantaneous. The heat transfer rate is not considered. All substances inside the containers have the same temperature.
- Interaction with the environment, except in a closed calorimeter, is always by heating or heat loss. The heating capacity or heat loss depends on the size of the object and the temperature difference between the object and the environment.
- The lids that close the containers can withstand any gas pressure inside the containers.

Simulation of processes in Virtual Lab is controlled using the **Simulation** button and the **Simulation speed** slider (Figure 21).

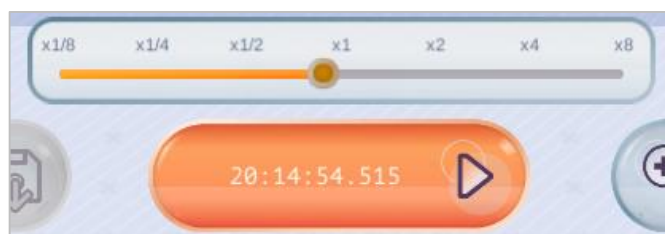
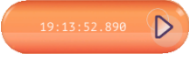


Figure 21 – Simulation speed slider and Simulation button

The simulation starts as soon as the Virtual Lab is started. If an error occurs that makes further simulation impossible, the simulation stops.

When button  is pressed, the simulation stops (but is not reset) and the button changes appearance — . A frame appears on the screen over the scene with a flashing pause icon in

the upper left corner . During a pause, all visual effects reflecting physical processes stop, for example: fire freezes, bubbles freeze. The simulation resumes when you click on the **Pause** button or when you interact with the instruments in any way: when you interact with instruments placed in the scene or when you start placing an instrument on the desktop.

The timer on the **Simulation** button displays the flow of time and is needed for relative estimation of the simulation speed. When you start Virtual Lab, the current system time is displayed. The rate of change of the timer accommodates the speed of the simulation.

The **Simulation speed** slider controls the simulation speed and displays the minimum and maximum possible speed (8 times slower and 8 times faster than real time, respectively), as well as the current user-configured speed (it corresponds to the slider position).

7.3 Camera control buttons

7.3.1 Zoom In button

When you click the **Zoom In** button , the camera moves one step closer to the desktop.

7.3.2 Zoom Out button

When you click the **Zoom Out** button , the camera moves one step away from the desktop.

7.3.3 Focus button

The **Focus** button  is available when there is a selected instrument on the desktop.

When a button is pressed, the camera moves closer to the selected object, giving the user the opportunity to examine instrument readings or observe a physical process. When you press the button again, the camera returns to the state it was in before you pressed the **Focus** button.

7.3.4 Whole scene button

When you click on the **Whole scene** button , the camera shifts so that the whole scene is displayed: the desktop is fully visible and horizontally it occupies the whole workspace.

8 Equipment panel



Figure 22 – Equipment panel

The **Equipment** panel (Figure 22) shows the cards of available objects. The cards are divided into four groups:

- containers;
- measuring instruments;
- heating devices;
- auxiliary appliances.

Each card contains a picture of an instrument and its name. For some objects, there is a constructor (icon ) that allows you to edit the settings that will be applied when the instrument is placed on the desktop.

Clicking on the object card (1 in Figure 23) activates the card: the screen displays an info panel with the description of the selected object (2), and if the object has a constructor, the screen also displays the constructor panel (3).

If you click again on the object card, the info panel and the constructor will be hidden.

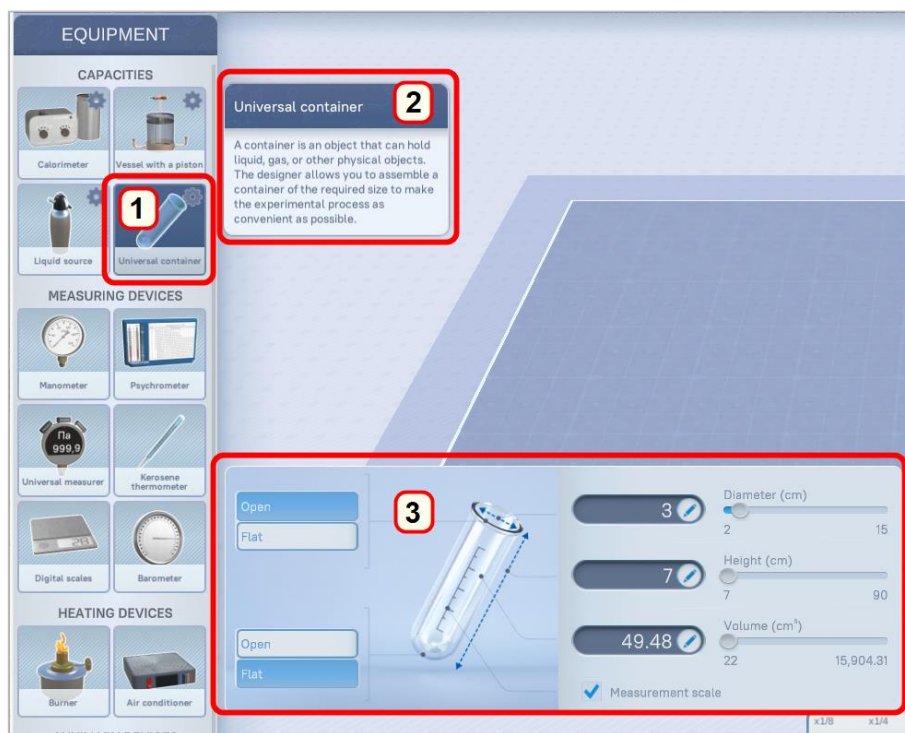


Figure 23 – Activating an object card

8.1 Object constructor

The object constructor (Figure 24) contains an image of the object and fields for setting its parameters.



Figure 24 – Object constructor

The composition of the parameters depends on the selected object:

- To the left of the object image, the parameter values with a fixed set of variants (1) are displayed. When an inactive option is selected, this value option becomes active (2).
- Parameters with value ranges are displayed to the right of the object image. For each parameter, there is a panel displaying the current value (3), a button to call up the numpad (4), a slider (5), and a slider bar (6). You can set the new parameter value in one of the following ways:
 - click in the slider area;
 - drag the slider bar;
 - press button (4) and set the exact value of the parameter on the numpad (see 8.2 “Numpad”).

- If a parameter has a fixed value **Yes/No** (e.g., availability of a heater connected to the calorimeter or a measuring scale on the universal container), its value is set with the checkbox (7).



Some parameters may be related to each other. For example, for the **Universal container** object, changing the **Diameter** or **Height** parameters will change the **Volume** parameter.

To close the constructor, click anywhere on the screen outside the constructor panel or scroll the mouse wheel. After closing the constructor, the changes made to the object parameters are saved. When you place an object on the desktop, the settings are automatically applied to that object. When another object of the same type is placed, the changes in the constructor will also be applied to it.

8.2 Numpad

Numpad (Figure 25) is used to set the exact value of the parameter within the available range.



Figure 25 – Numpad

The current value of the parameter is displayed in the input field (1). Above this value is the step of parameter change within the available range (2).

Buttons (3) and (4) are used to set the minimum or maximum value of a parameter from the available range.

The **Value validation** button (5) has two functions:

- rounding of the entered value with the accuracy acceptable for the indicator;
- setting the nearest valid value in the field if the entered value is out of range.

Buttons (6) and (7) are used to clear the input field.

When button  is pressed, the entered parameter value is saved and the numpad is closed. If the entered parameter value does not match the range or if the input field is empty, the button is locked.

To close the numpad without saving the changes you made, press button  or anywhere on the scene outside the numpad.

9 Interaction with instruments

9.1 Creating an instrument

To create an instrument on your desktop:

- 1) Hover the pointer over the card of the desired object on the equipment panel (see section 8 “Equipment panel”).
- 2) If you need to customize the parameters of the object you are creating, click on its card. The screen will display the info panel and the constructor panel (Figure 23). Set the parameter values in the constructor (Figure 24).
- 3) Drag an object from the equipment panel to the desktop area. When the pointer moves to the desktop area, a three-dimensional model of the instrument to be created appears under the pointer (Figure 26). Release the pointer at the place on the desktop where you want to place the instrument.



Figure 26 – Creating an instrument

When the instrument is dragged into an area where it cannot be placed (for example, the edge of the desktop or a space occupied by another instrument), the color of the instrument changes to red (Figure 27). If you release the pointer at this point, the instrument will not be created.



Figure 27 – Instrument in an area that is not available for placement

9.2 Selecting an instrument in the scene

To select an instrument placed on the desktop, click on it with the left mouse button or with your finger when using the touch screen. The selected object gets a white outline (Figure 28). At the same time,

different buttons can be displayed depending on the actions that can be taken with the instrument (e.g.,

 — close the lid of the container,  — there is an enclosed object inside the container, etc.).



Figure 28 – Selecting an instrument

9.3 Moving the instrument

To move the instrument in the workspace, click on it and drag it. The instrument will follow the pointer. Release the pointer at the place on the desktop where you want to place the instrument. If the instrument is in an area where it cannot be placed (e.g., the edge of the desktop or a space occupied by another instrument), the color of the instrument changes to red (Figure 27). If you release the pointer at this point, the instrument will “return” to its original position.

You can place the object inside the container. To do this, click on an object and drag it onto the container. When objects are ready to interact, the object being moved “sticks” to the container. If the instrument is inside a container, separate the container to remove it. It will have a white outline. The nested object button  will be displayed on the container (Figure 29).



Figure 29 – Availability of a nested object in the calorimeter

Press button  and drag the pointer to the side. The object will be removed from the container.

9.4 Deleting an instrument

To delete an instrument from the workspace, drag it outside the desktop boundaries. When crossing the border, the instrument will first turn red — this means that the instrument can no longer be placed in

this area. Then, a red button  will appear above the instrument — it means that in this zone, the instrument will be deleted from the scene when the pointer is released (Figure 30).



Figure 30 – Deleting an instrument

You can delete all instruments from the desktop using the **Clear scene** button  on the control panel (see 7.1.1 “Clear scene button”).

9.5 Transfer

You can transfer fluid from one container to another. You can do this provided that the container into which you want to transfer the fluid is empty or there is already some fluid of the same type you are going to transfer.

Place two containers on the work table for transferring. At least one of them must contain fluid (Figure 31).



Figure 31 – Fluid source and container

Drag the container from which you want to transfer the fluid to the container into which you want to transfer the fluid. Release the pointer when both containers have blue outlines, indicating that the objects are ready to interact (Figure 32). After that, the transfer panel will open (Figure 33).



Figure 32 – Containers are “ready for transfer”

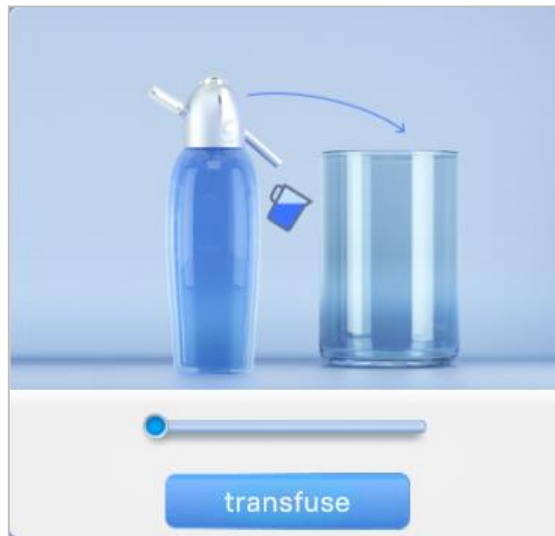


Figure 33 – Transfer panel

Move the slider to indicate the amount of fluid to be transferred.

The rightmost position of the slider corresponds to the volume of fluid that can be transferred. If you try to transfer more fluid from the first container into the second container than can fit into the second container, the part of the fluid that did not fit into the second container will remain in the first container (Figures 34–36). By moving the slider (Figure 35) from the leftmost to the rightmost position, you can make sure that the volume of fluid that can be transferred from the first container cannot exceed the free volume in the second container.

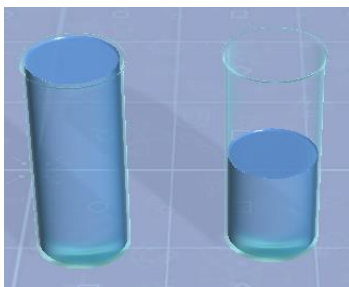


Figure 34 – Preparing for transfer

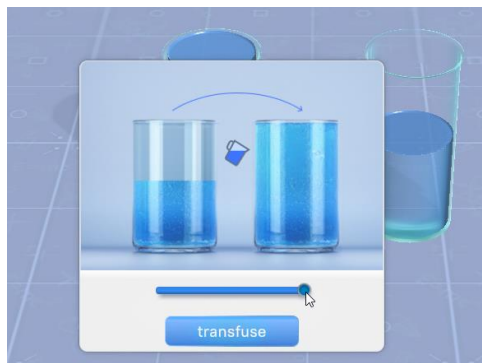


Figure 35 – Transfer

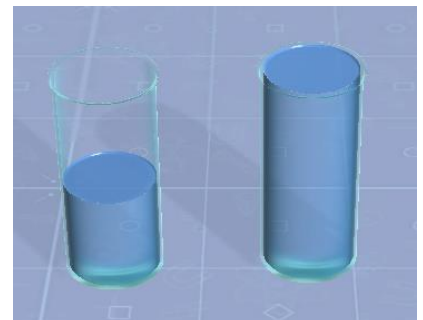


Figure 36 – Transfer outcome

10 Description of instruments

10.1 Containers

10.1.1 Calorimeter

The calorimeter is a container with thick walls (Figure 37).



Figure 37 – Calorimeter with electric heater

As part of the experiments, it is considered to have an isolated heat transfer process. With the lid open, the calorimeter interacts with the environment. If the lid is closed (press button ) , it becomes a “universal thermos”, i.e., it does not exchange heat with the environment. The only way to increase the heat (energy) inside the calorimeter is to turn on the built-in electric heater.

To place a calorimeter with a heating element on the desktop, check the **Connect heater** checkbox on the Calorimeter Constructor panel.

The heater can be switched on by pressing button  . The green indicator (1) lights up when the instrument is in operation. The red indicator (2) lights up when the temperature inside the calorimeter reaches 120 °C and the heating of the substance inside the calorimeter stops. The red light blinks when the lid of the calorimeter is open and the fluid in the calorimeter is interacting with the environment.

The heater voltage and resistance can be adjusted using buttons  (by pressing them and pulling left or right).

The lid of the calorimeter has a port for mounting a thermometer (Figure 38). The pressure gauge and the universal meter are installed in the center of the lid (Figure 39).

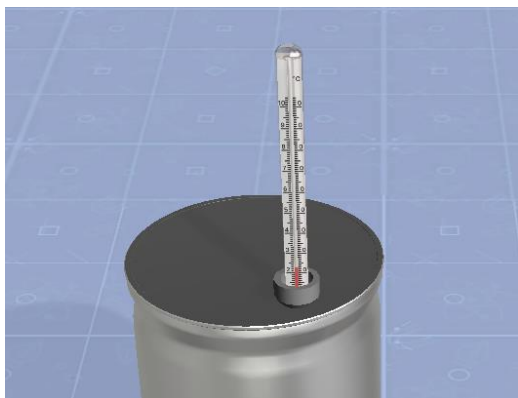


Figure 38 – Thermometer on the calorimeter lid



Figure 39 – Universal meter on the calorimeter lid

10.1.2 Piston container

A piston container is used to perform experiments with gas. A piston in a container is used to change the volume that can be occupied by a gas of a selected type contained within the container.

Ideal gas formulas are used in the calculations. Also, the calculations do not include the heating or cooling of the gas during compression or expansion. The gas temperature inside the container is only affected by the ambient temperature (this is set with button ) or, if the container is mounted on an air conditioner, by the temperature of the air conditioner.

The piston can have a fixed handle (push button  — Figure 40), and hence the volume of gas inside the container. Once you fix the handle, you can change the volume of gas inside the piston by pulling the handle up or down. A universal meter or pressure gauge can be installed in special connectors on the sides of the piston.



Figure 40 – Pressure gauge mounted on the piston container

10.1.3 Fluid source

A fluid source (Figure 41) is an abstract infinite container from which a fluid of a given temperature can be transferred to another container. In the source constructor (see 8.1 “Object constructor”) you can select the fluid and its temperature. The source is a thermos and is not involved in interaction with the environment: it is neither heated nor cooled.



Figure 41 – Fluid source

10.1.4 Universal container

A universal container is an object that holds a fluid, gas, or other physical object. Examples of containers are shown in the Figure 42.

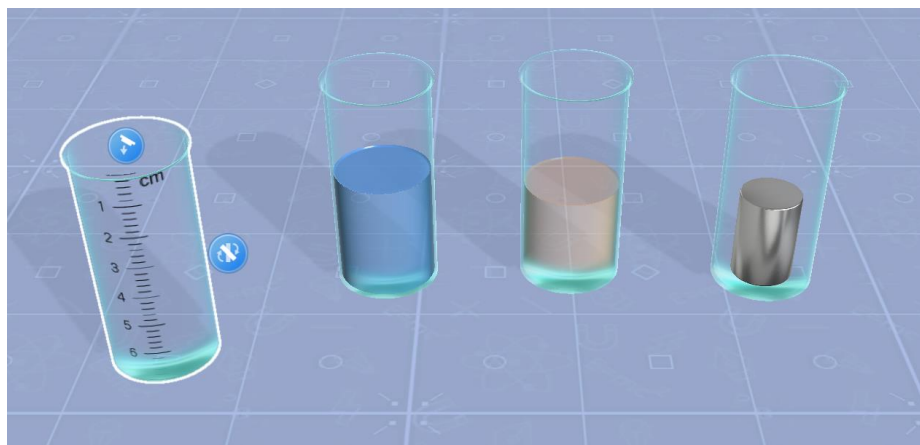


Figure 42 – Examples of containers

The constructor allows you to build a container of the required size, with or without measuring scale. The measuring scale is necessary to control the volume of the fluid to be transferred, i.e., in order to account for the volume of the fluid when transferring from one container to another, at least one of these containers must be provided with a measuring scale. For example, when transferring fluid from a source to a container without a scale (Figure 43), you can only approximate the volume of fluid to be transferred using the slider bar. When transferring fluid from the source to a container with a scale (Figure 44), you can precisely set the volume by opening the valve with button .



Figure 43– Transferring fluid into a container without a scale

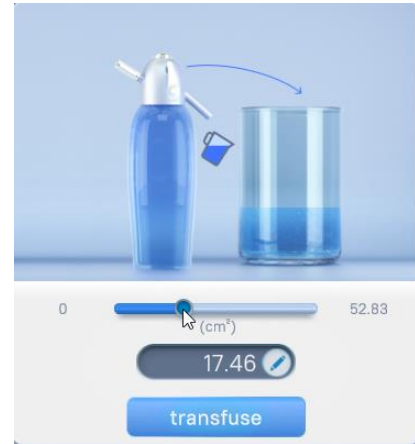


Figure 44– Transferring fluid into a container with a scale

The scale is placed on the container wall in centimeters and graduated from top to bottom. It is not designed to measure the volume of fluid but rather the height of the fluid column (and thus the pressure inside the container).

The container can be closed and opened (buttons  and ). You can also turn the container over (button ), create a container open at both ends, and close the ends of the container with lids (the lids themselves do not contribute to the calculations - they do not affect the volume and do not contribute to heat transfer, just like the walls of the container).

10.2 Measuring instruments

10.2.1 Pressure gauge

The pressure gauge is designed to measure the pressure of a fluid or gas in a container. It is connected via the container lid or a special connector (Figure 45). The pressure gauge scale is marked in Pascals.

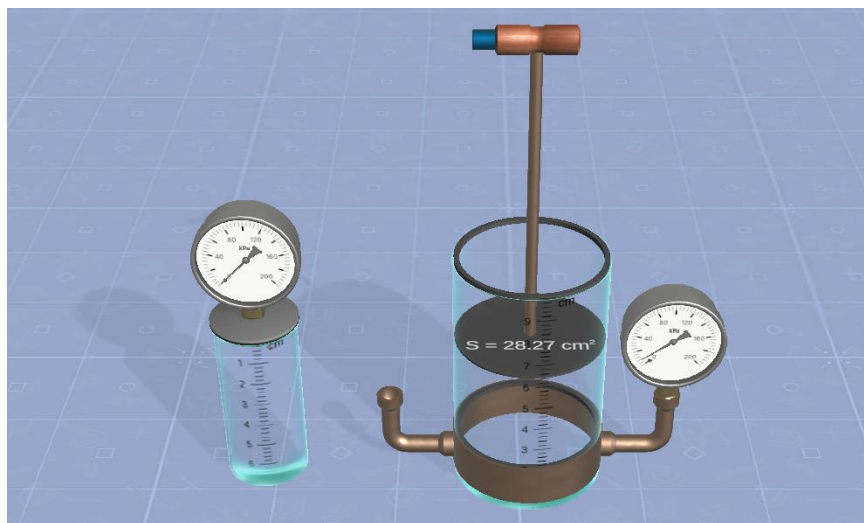


Figure 45 – Connecting the pressure gauge

10.2.2 Psychrometer

Psychrometer (Figure 46) is designed to determine air humidity and measures only environmental parameters. The instrument contains two thermometers. The active area of one thermometer is wetted with room temperature water. An auxiliary table allows you to compare thermometer values and determine humidity.

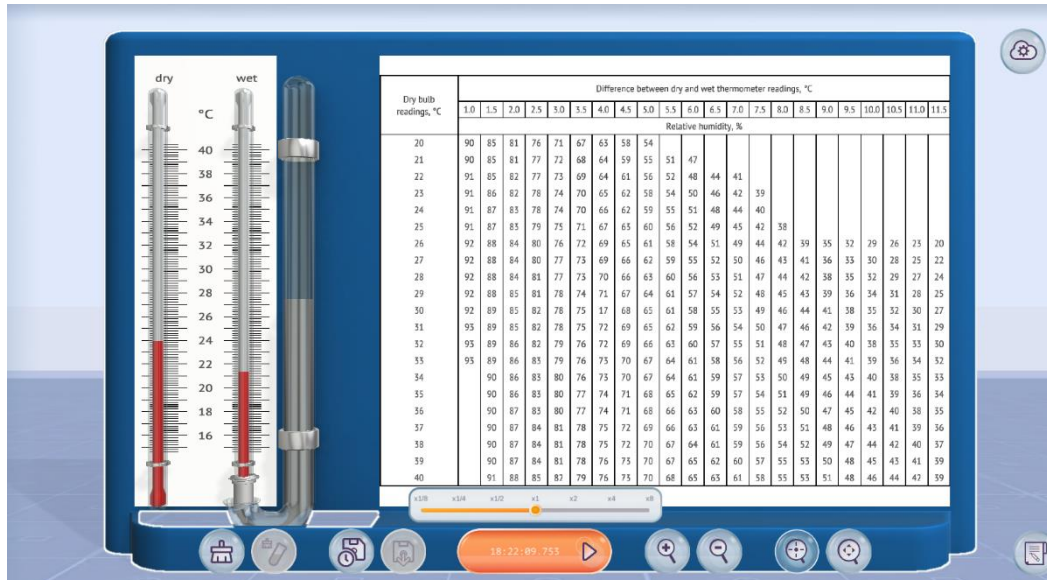


Figure 46 – Psychrometer in camera focus mode

10.2.3 Universal meter

Universal meter is designed to determine temperature, pressure, and humidity. The instrument is connected via the container lid or a special connector.

You can select the parameter to be measured using the buttons displayed above the selected instrument: , , or . When measuring humidity, the instrument only interacts with the environment. For example, if an instrument showing ambient humidity (left in Figure 47) is placed on a test tube, it will display dashes (right) instead of the humidity value.



Figure 47 – Relative humidity readings on the universal meter

10.2.4 Kerosene thermometer

The thermometer is used to determine the temperature of a substance. It can be placed inside the container — it will be placed along the front wall of the container (Figure 48) and measure the temperature inside the container.



Figure 48 – Measuring the temperature of a substance

10.2.5 Digital scales

Digital scales (Figure 49) are a platform for weighing other objects. A calorimeter, universal container, gas balloon or metal cylinder can be mounted on the scales. When multiple objects are placed on the scales, they display their total weight.

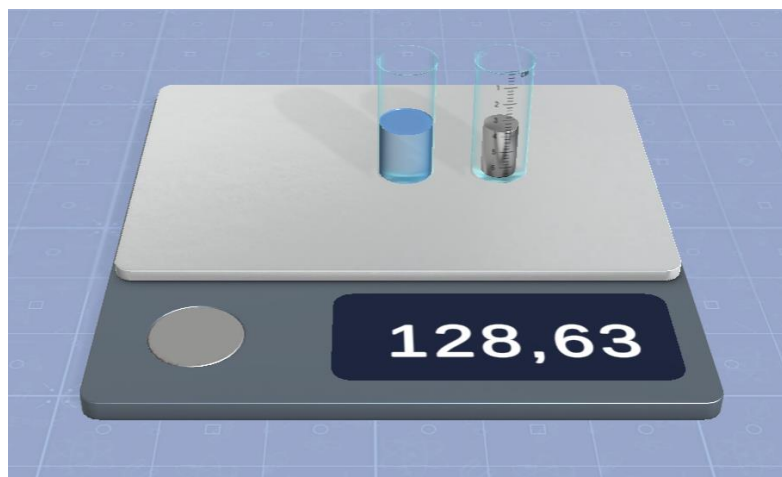


Figure 49 – Digital scales

10.2.6 Barometer

The barometer (Figure 50) is designed to determine the atmospheric pressure in the environment. It has two scales: in millimeters of mercury column and in Pascals.

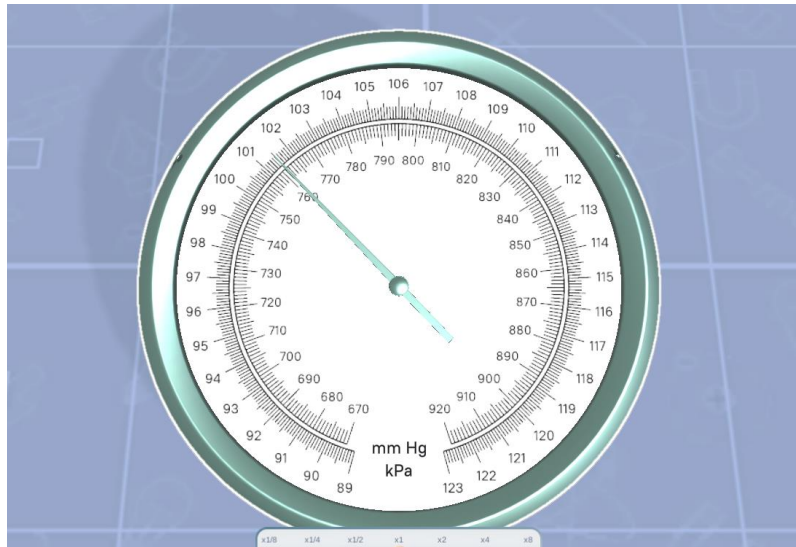


Figure 50 – Barometer in camera focus mode

10.3 Heating devices

10.3.1 Burner

The burner is a heating device that can be switched on (button ) or off (button ) in Figure 51).



Figure 51 – Burner

10.3.2 Air conditioner

A portable air conditioner (Figure 52) is a device for heating or cooling objects standing on it, such as a piston or universal container. Press button  to turn on the air conditioner. To change the temperature, press button  and drag the pointer to the left or right (Figure 52).



Figure 52 – Changing the air conditioner temperature

10.4 Auxiliary appliances

10.4.1 Gas balloon

A gas balloon is a metal balloon with a pressure gauge connected (Figure 53). It is assumed that an ideal gas is pumped into the balloon.

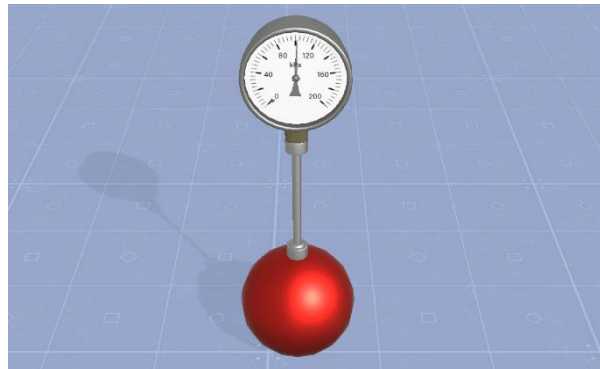


Figure 53 – Gas balloon

10.4.2 Tripod

A tripod (Figure 54) consists of a stand on which various instruments can be placed and a vertical stand on which one or more holders can be attached.

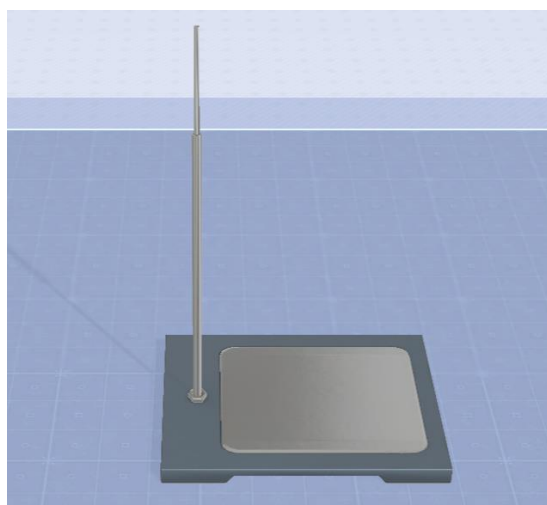


Figure 54 – Tripod

Before creating a tripod in the constructor, you should set its height considering the height of the instruments to be placed on it.

10.4.3 Holder

The holder (Figure 55) is designed to be mounted on a vertical tripod stand. Various instruments such as a gas balloon, universal container, etc. can be placed in the foot of the holder.

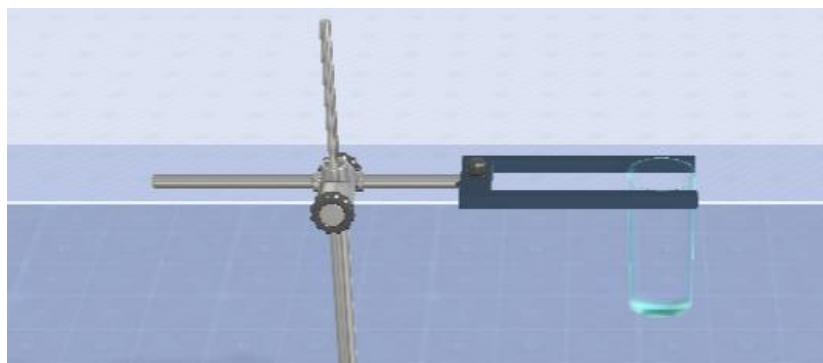


Figure 55 – Universal container in the holder foot

Multiple holders can be attached to the tripod. You can move the holders along the rack by the holders themselves. Besides, in the case when two holders are fixed on the tripod and the instruments placed on them visually overlap, one of the holders can be moved by the instrument fixed on it (Figure 56). But in this case, if the visual overlap between the instruments disappears, the instrument is removed from the clamp.

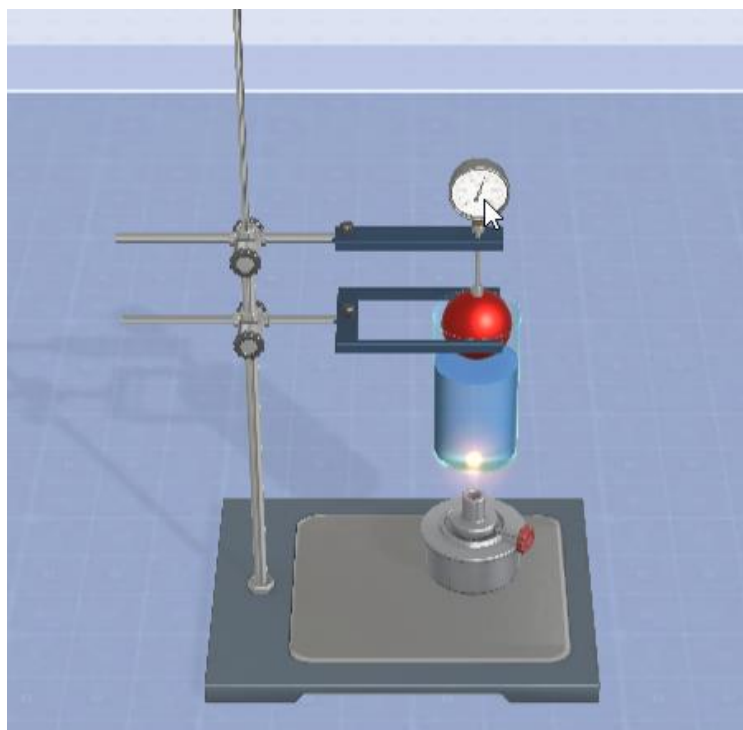


Figure 56 – Moving the instrument on a tripod

10.4.4 Metal cylinder

A cylinder made of a selected metal. The parameters of the cylinder and the substance of which it is composed are set in the constructor when it is created. Examples of cylinders are shown in Figure 57.

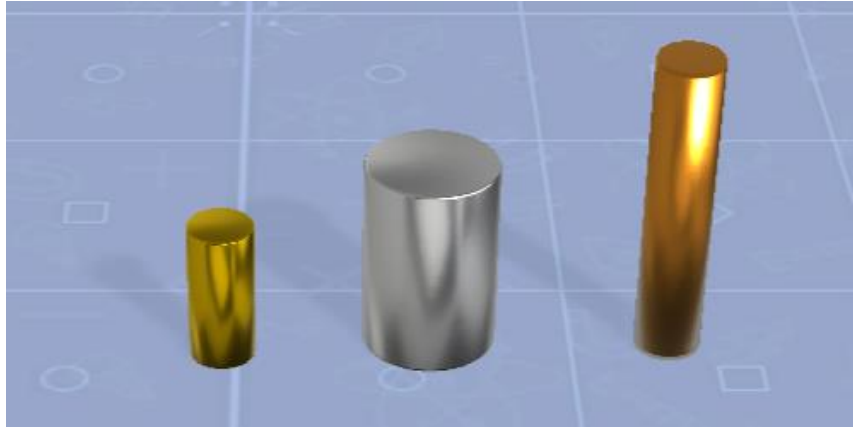


Figure 57 – Metal cylinders

The cylinder can be placed inside the container. At the same time, it is inserted into the slot and held at the bottom of the container. For this reason, the aluminum cylinder does not float when mercury is filled into the container.