



Virtual laboratory



PHYSICS

Mechanics

User
manual



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Terms and definitions

The following common terms and definitions are used in the User's Guide:

Term	Definition
Virtual lab	Application Virtual laboratory “Physics”, section “Mechanics”
Scene	Virtual three-dimensional space, where the user can interact with Virtual Lab objects, as well as data of the current study (positions of objects, their parameters, etc.)
Desktop	The part of the scene, where the user can place and interact with Virtual Lab objects
Process simulation	The process of interaction of objects in the scene modeled in the Virtual Lab
Camera	Scene tool, which allows the user to observe everything going on in the Virtual Lab
Click	The action to take: — when using the mouse — move the mouse pointer to the object, press and release the <u>left mouse button</u> without moving the pointer; — when using the touch screen — press your finger on the object and release without moving your finger
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

1 System Requirements

Minimum system requirements for the application **Virtual laboratory “Physics”, section “Mechanics”** 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

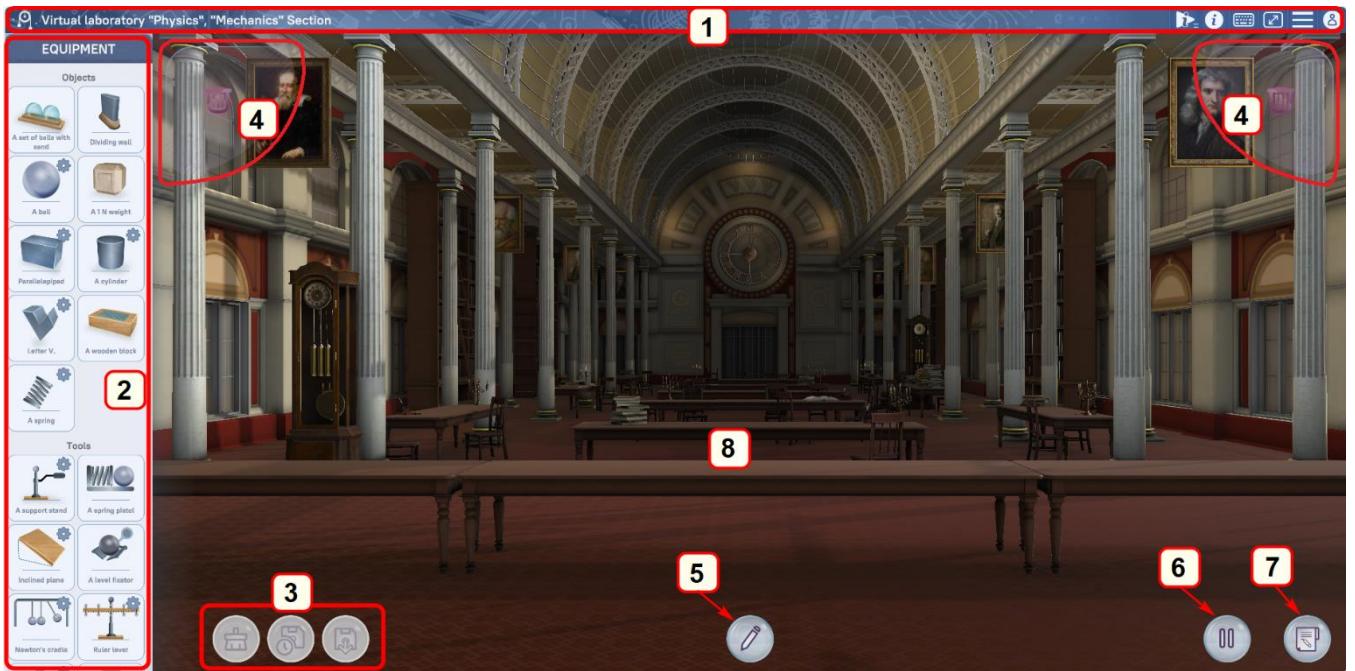


Figure 1 – Virtual Lab interface

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

- 1) The **Application Header panel** contains the Virtual Lab logo and name (left) and a set of functional buttons (right) (see section 4 “Application Header panel”).
- 2) The **components panel** contains instrument cards that can be used in the scene (see section 9 “Components panel”).
- 3) The **control panel** contains buttons to control the scene (see 5 “Control panel”).
- 4) **Object removal zones** (see 10.6 “Removing objects”).
- 5) **Measurement and marking menu** (see section 6 “Measurement and marking menu”).
- 6) **Time Freeze button** (see section 7 “Time freeze”).
- 7) **Scene card button** (see section 8 “Scene card”).
- 8) The **Desktop** is the part of the scene, where you can create schematics from the available equipment and interact with them.

3 Camera control

Control the camera with the mouse or fingers (when using the touch screen).

When the application loads, the camera is in the default position — pointing at the center of the desktop.

Rotate the mouse wheel to zoom in/out the camera. When using the touch screen, touch the screen with two fingers, spread them apart, or bring them together.

To move the camera, click on any free space in the scene with the left or right mouse button (or with one finger when using the touch screen) and, without releasing, drag the pointer in the desired direction. You can also move the camera along the desktop while moving an object: to do this, move the cursor with the object to the right or left edge of the workspace and drag further (Figure 2).

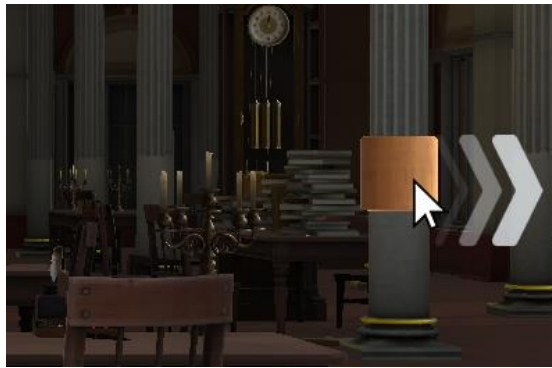


Figure 2 – Moving the camera while the object is moving

4 Application Header panel

The **Application Header** (Figure 3) panel contains the Virtual Lab logo and name (left) and a set of functional buttons on the right:



Figure 3 – Function buttons of the Application Header panel

- button to call up video instruction  (see 4.1 “Video Instruction”);
- button to enable/disable the hint mode  (see 4.2 “Hint mode”);
- button to enable/disable the virtual keyboard mode  (see 4.3 “Virtual Keyboard”);
- button to enable/disable the fullscreen mode  (see 4.4 “Fullscreen mode”);
- button to call up the scene menu  (see 4.5 “Scene menu”);
- profile control button  (see 4.6 “User Profile”).

4.1 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 4).

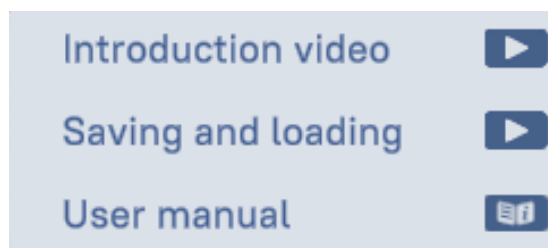


Figure 4 – Educational material selection menu

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 5).

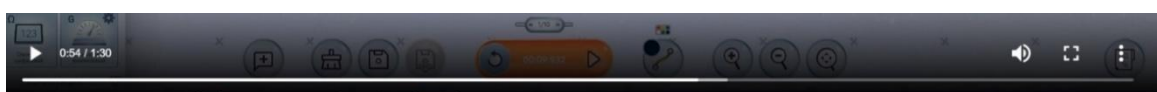


Figure 5 – Player controls

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

4.2 Hint mode

To switch to the interactive hint mode, click the **Hint Mode** toggle button  in the **Application Header** panel. In the scene, hint points will appear next to the objects (Figure 6).

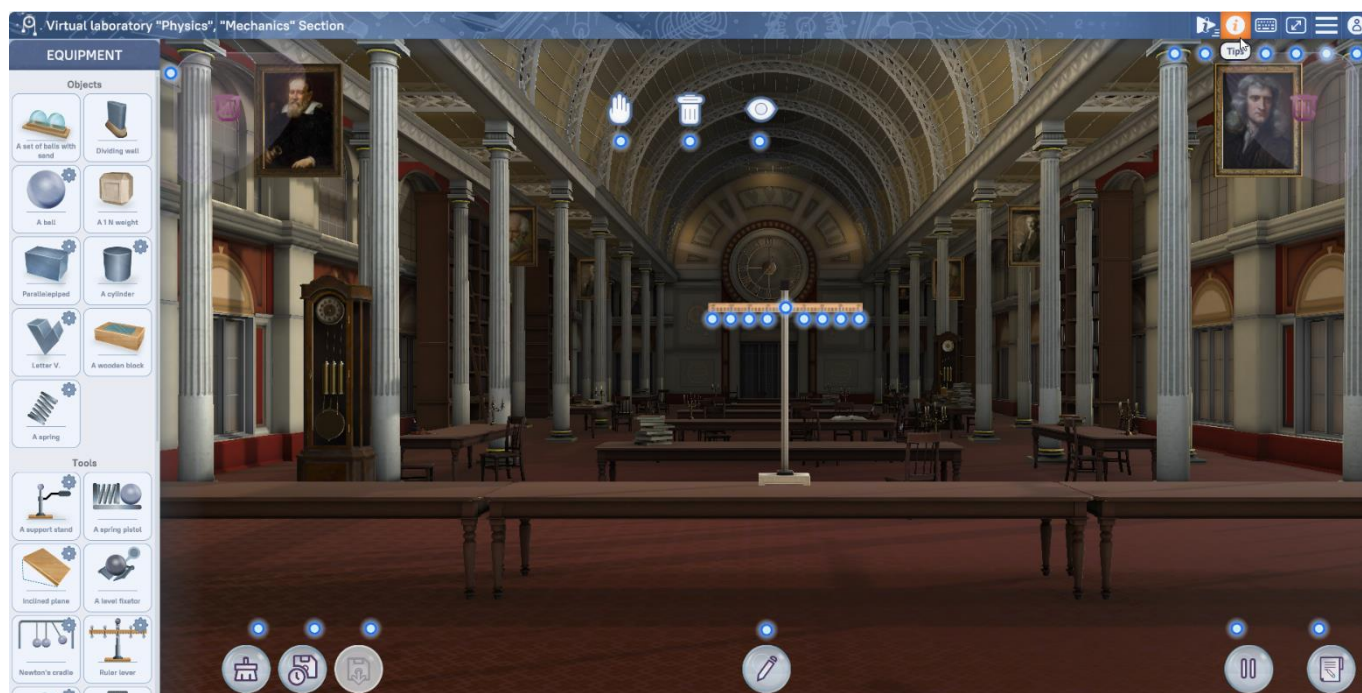


Figure 6 – Hint mode

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

Hint points change the outline color depending on how the user views the hint (Figure 7):

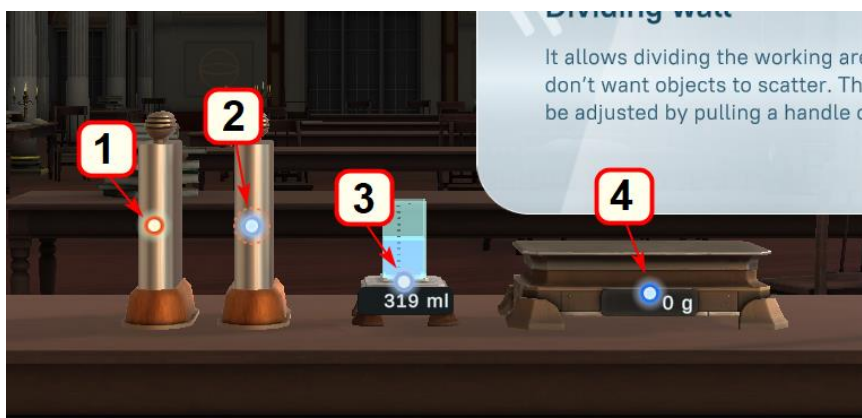


Figure 7 – Point outline color options

- 1) Orange outline point  — the hint point is open on the screen (as in Figure 7).
- 2) If several objects have the same hints, and one of such hints is currently open, the hint points of other objects with the same hint will have a double outline: gray and orange dashed .
- 3) Gray outline point  — the user has previously viewed and closed the hint.
- 4) Blue outline point  — the user has not yet viewed this hint.

Besides, the Virtual Lab has three hidden icons with hints (Figure 8): **Moving objects** (1), **Deleting objects** (2), **Moving around the scene** (3). They are only visible in hint mode.



Figure 8 – Icons with hints at the top of the workspace

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

4.3 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 9).



Figure 9 – Virtual Keyboard

The virtual keyboard has two layouts: Latin and Symbolic. To switch the layout, press button  on the virtual keyboard.

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

4.4 Fullscreen mode

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

4.5 Scene menu

Working in the Virtual Lab, 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 4.5.4 “Viewing and loading user scenes”);

- share a link to the current scene (see 4.5.5 “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 10).

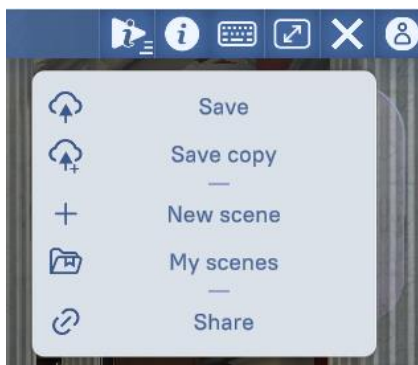


Figure 10 – Scene menu

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

4.5.1 Saving a scene

To save the created scene in the **My scenes** library, select the **Save** item in the scene menu (Figure 10).

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 11).

Figure 11 – Save Scene form

Enter the name of the scene to be saved (max. 36 characters) and 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, these values will be displayed when saving the scene (see section 8 “Scene card”).

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 4.3 “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 .

4.5.2 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 10). The form of saving a copy of the scene will be opened, just like the form of saving a scene (Figure 11).

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 already saved, the **Scene name** field displays the previously saved scene name with the copy number in brackets — **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, these data will be displayed when saving the scene copy (see section 8 “Scene card”).

Press button  to save a copy of the scene.

Once you save a copy, you will continue to work in this scene copy. 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 .

4.5.3 Creating a new scene

To create a new scene, select the **New scene** item in the scene menu (Figure 10). If there is unsaved data in the scene, a window with a warning about possible data loss will open (Figure 12).

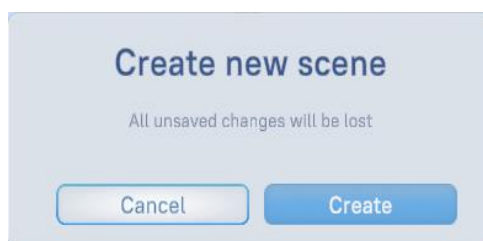


Figure 12 – “Creating a new scene” window

To avoid losing the current data, press button  and continue working with 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.

4.5.4 Viewing and loading user scenes

To view a list of your saved scenes, select **My scenes** from the scene menu (Figure 10). The **My scenes** library page will open (Figure 13).

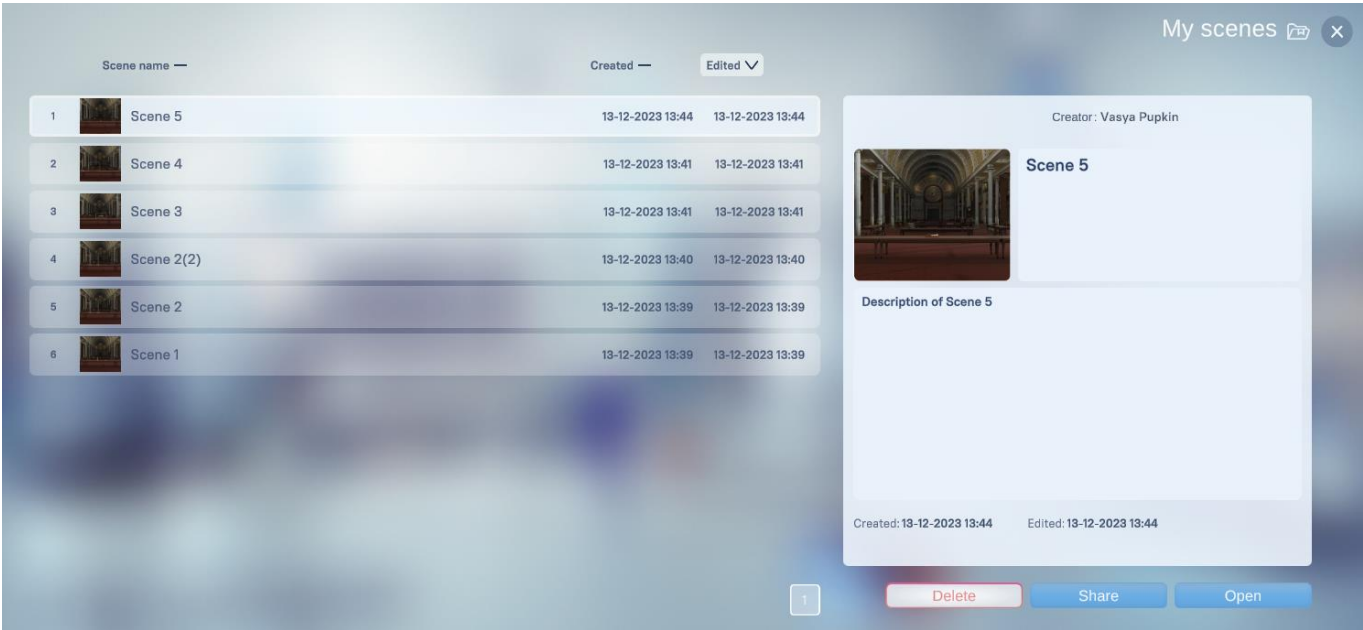
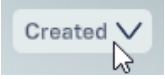


Figure 13 – My scenes library

On the left side of the screen, in the table, a list of all saved scenes is displayed. The list can be sorted by name, creation date, and modification date. To sort the list, click on the name of the corresponding table column (**Name**, **Created**, or **Modified**). The icon  next to the column 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 using the buttons with page numbers located on the right side 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 the selected scene, delete it, or share a link to it.

4.5.5 Saving a link to a scene

To share a link to the current scene, select the **Share** item in the scene menu (Figure 10). 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 11). You can save or send the link from the clipboard to someone.

4.6 User Profile

When you click the **Profile** button  on the **Application Header** panel, the user menu opens and the user login (Figure 14) is displayed above it.



Figure 14 – 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 [Logout](#) to change the current account, or click [Cancel](#) to continue using the current account.

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

5 Control panel

The control panel is located at the bottom of the screen and consists of three buttons (Figure 15):

- 1) **Clear Scene** button (see 5.1 “Clear Scene button”),
- 2) **Save point** button (see 5.2 “Save point button”),
- 3) **Return to save point** button (see 5.3 “Return to save point button”).



Figure 15 – Control panel

5.1 Clear Scene button

The **Clear Scene** button  is available if at least one object is placed in the scene. If you press the button, the confirmation window opens (Figure 16).

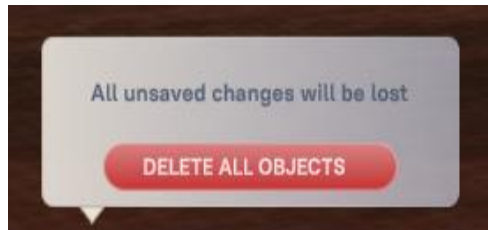


Figure 16 – Scene clearing confirmation window

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.

5.2 Save point button

The save point is the fixed state of the scene. To create a save point, click button . The application will save object settings, their location in the scene, and the time on the timer. Selection of objects in a scene is not saved. The application can store only one scene state. Re-saving a scene changes the previously recorded state of the scene to its current state.

The **Save point** button  is available if at least one object is placed in the scene.

5.3 Return to save point button

The **Return to save point** button  becomes available after creating a save point using the **Save point** button . Press button  to return to the last saved scene state.

6 Measurement and marking menu

To expand the menu, press button  at the bottom of the screen (5 in the Figure). The menu consists of four buttons (Figure 17):

- 1) Ruler (see 6.1 “Ruler”);
- 2) Thin line (see 6.2 “Lines”);
- 3) Thick line (see 6.2 “Lines”);
- 4) Eraser (see 6.3 “Eraser”).



Figure 17 – Measurement and marking menu

To close the menu, click on cross .

6.1 Ruler

To create a ruler, click on its image in the measurement and marking menu  (Figure 17). The ruler will appear in the center of the screen.

To move the ruler, right-click it or use two fingers (if using the touch screen) and drag it to the desired location. The ruler can be moved strictly vertically or horizontally — to do this, left-click it or use one finger and drag it up, down, right, or left to the desired position.

To rotate the ruler, hover the pointer over it and rotate the mouse wheel or press with two fingers. The ruler will rotate relative to the pointer or finger position point.

To adjust the ruler length, drag the right edge to the left or right.

To align the ruler vertically or horizontally, click icon . This icon is available when the ruler position differs from strictly vertical or strictly horizontal.

To delete a ruler, click on its image  or close the menu.

6.2 Lines

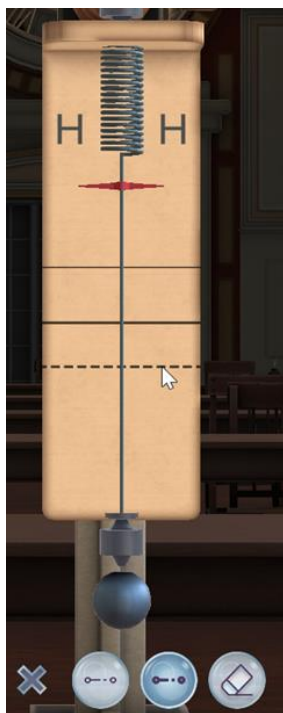


Figure 18 – Drawing lines
on a dynamometer
without scale

6.3 Eraser

To remove lines on the desktop or dynamometer, use the **Eraser** tool. Click button  in the measurement and marking menu (Figure 17), then click on the line you want to delete. To delete multiple lines, also press button , hold down the pointer and drag across the lines you want to delete.

The **Lines** tool is used to draw lines on the desktop and on the dynamometer without scale (see 11.3.5 “Dynamometer”). Select the line thickness by pressing the button: for thin lines — , for thick lines — .

To create a line, select a thickness, point to a drawing surface (desktop or dynamometer), and hold down the pointer. A dotted line (Figure 18) will be displayed on the surface. Drag the pointer to the desired line position and release it — a solid line of the selected thickness will be created where you release the pointer.

To create a line in the exact location you want, select a thickness and click on the drawing surface. The line created will pass through the click point.

7 Time freeze

To stop the flow of time in the application, press button  (6 in Figure 1). Icon  on the button will change to . All processes in the scene will be suspended for the duration of the freeze. To return to work, click  or drag any object on the desktop.

Use freeze to capture moving objects (such as a pendulum ball or magnetic spring connector) with the pointer.

8 Scene card

The scene card (Figure 19) allows you to fill in and view the information about the scene that you will need when saving the scene. 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 4.5.1 “Saving a scene” and 4.5.2 “Saving a copy of the scene”),
- when you select a scene in the **My scenes** library (see 4.5.4 “Viewing and loading user scenes”).

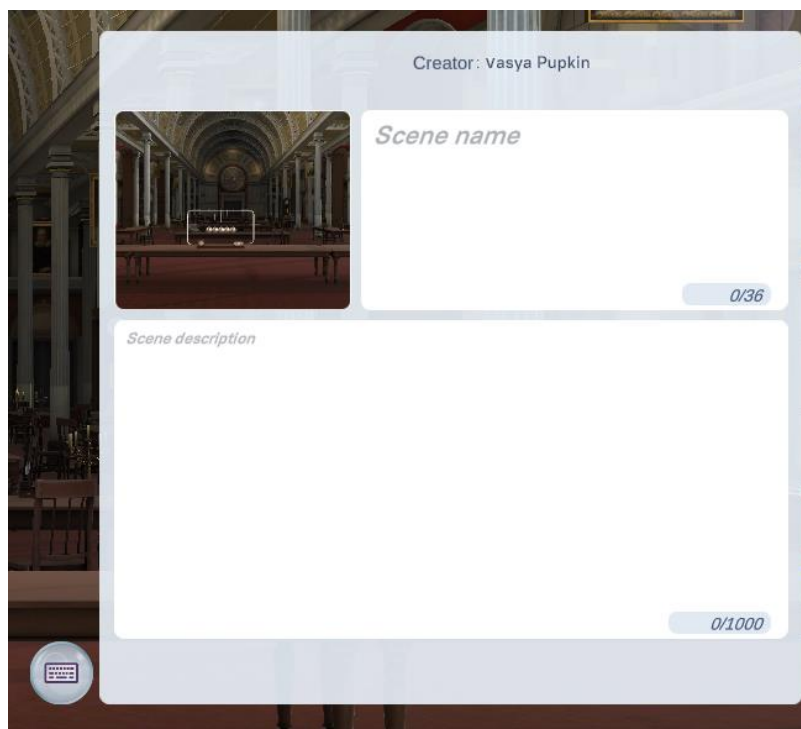
The image shows a 'Scene card' overlay on a background image of a grand hall. The card has a light blue header with the text 'Creator: Vasya Pupkin'. Below the header, on the left, is a small square thumbnail image of the hall. To the right of the thumbnail is a large text input field labeled 'Scene name' in a light blue font. Below the 'Scene name' field is a smaller text input field labeled 'Scene description' in a light blue font. At the bottom right of the 'Scene name' field is a small blue button with the text '0/36'. At the bottom right of the 'Scene description' field is a small blue button with the text '0/1000'. In the bottom left corner of the card, there is a circular button with a document icon and the text 'Scene card'.

Figure 19 – Scene card

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 will be empty.

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 4.3 “Virtual Keyboard” and 4.5.1 “Saving a scene”.

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

9 Components panel

The Components panel is located on the left side of the Virtual Lab screen (Figure 1) and contains cards of equipment that can be used in the scene (see section 11 “Describing the objects”).



Equipment cards are grouped by category (Figure 20):

- objects (see 11.1 “Objects”);
- instruments (see 11.2 “Instruments”);
- meters (see 11.3 “Meters”).

Each card contains a picture and the name of the equipment. The cards of some objects are marked with icon . These objects can be customized before placement in the scene using the object constructor.

Clicking on the object card (1 in Figure 20) opens the info panel with the description of the selected object (2), and if the object has a constructor, the constructor panel (3) (see 9.1 “Object constructor”).

Clicking the card again closes the info panel and the constructor panel.

Figure 20 – Equipment tab

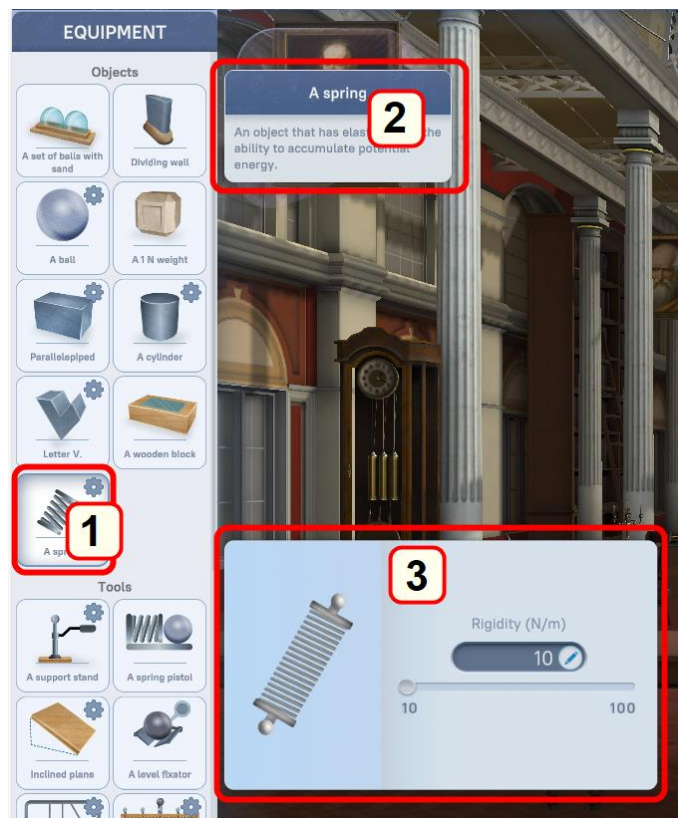


Figure 21 – Activating an object card

9.1 Object constructor

The object constructor contains an image of the object and fields for setting its parameters (Figure 22).



Figure 22 – Object constructor

The application provides three options to customize the parameters:

- selecting a value from the list;
- selecting a value within the range;
- selecting a yes/no value.

To set the parameter value from the list, click on the desired option (1 in Figure 22).

For parameters with in-range setting, the range of possible values (4) is indicated. To set the exact value of a parameter within the range, click on icon  (2) and enter the value using the numpad (see 9.2 “Numpad”). You can also set the value inside the range using the slider bar (3): drag the slider bar to the desired position on the slider, or click on the slider to move the slider bar to the click point.

The default setting for all parameters with a yes/no selection is “no”. To set the parameter to “yes”, click in the box to the left of the parameter name — a “check mark” (5) will be displayed in the box.

 Some parameters may be related to each other. For example, for the object **Measuring container**, a change in dimensions will result in a change in volume.

To close the constructor, click on the object card on the **Equipment** tab. The object settings are saved after the constructor is closed. If you place another object of the same type in the scene, the changes in the constructor will be applied to it as well.

9.2 Numpad

Numpad (Figure 23) is used to set the exact value of a parameter within the available range. Click icon  in the object constructor (see 9.1 “Object constructor”) to call up the numpad.



Figure 23 – Numpad

The current value of the parameter is displayed in the input field.

Use the virtual keyboard on the numpad or the keyboard on your device to enter a parameter value. To delete the last digit of the entered value, click icon .

To apply the changes, press button . The button becomes active when the correct parameter value is set in the input field.

10 Interaction with instruments

10.1 Creating an instrument

To create an instrument on your desktop:

- 1) 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 21). Set the parameter values in the constructor (Figure 22).
- 2) Drag the object to the desktop and drop it where you want to place the instrument. When the pointer moves to the desktop area, a three-dimensional model of the instrument to be created appears under the pointer.

The instrument model changes color to red in an area where the instrument cannot be placed. If you release the pointer at this point, the instrument will not be created (Figure 24). Until the object is placed on the desktop, time in the scene stops, all instruments freeze.

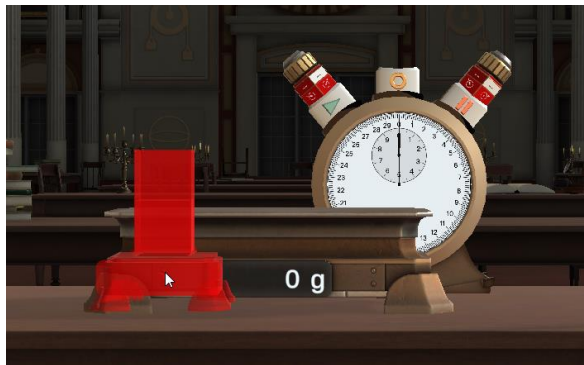


Figure 24 – Instrument in an area that is not available for placement

To customize an object already placed in the scene, use the customization elements of the object itself (toggle buttons, knobs, switches, controls) — press or drag in the desired direction, just like in reality.

10.2 Moving objects

To move an object, hold the pointer on a part of the instrument that does not interact with other equipment (such as a tripod) and drag it to the desired location. Some instruments can only be moved along the desktop (e.g. ruler lever and stopwatch).

Instruments on the desktop cannot overlap: if an instrument is moved to an unavailable area, its model changes color to red (Figure 24). Some instruments can be placed one behind the other.

10.3 Rotating objects

To rotate the instrument, point the pointer at it, press the left mouse button, and rotate the mouse wheel. The object will rotate around the pointer.

When using the touch screen, use two fingers to grip the instrument and rotate one finger around the other. The object will rotate around a fixed finger.

Objects that move only along the desktop cannot be rotated.

10.4 Connecting objects using magnetic connectors

Instruments and objects can be connected to each other using magnetic connectors (Figure 25).



Magnetic connectors have no weight and do not bring electromagnetic forces into the scene.

Some items have magnetic connectors installed by default (e.g., tripod and dynamometer). For some objects (for example, for a ball), magnetic connectors can be added in the object constructor (see 9.1 “Object constructor”).

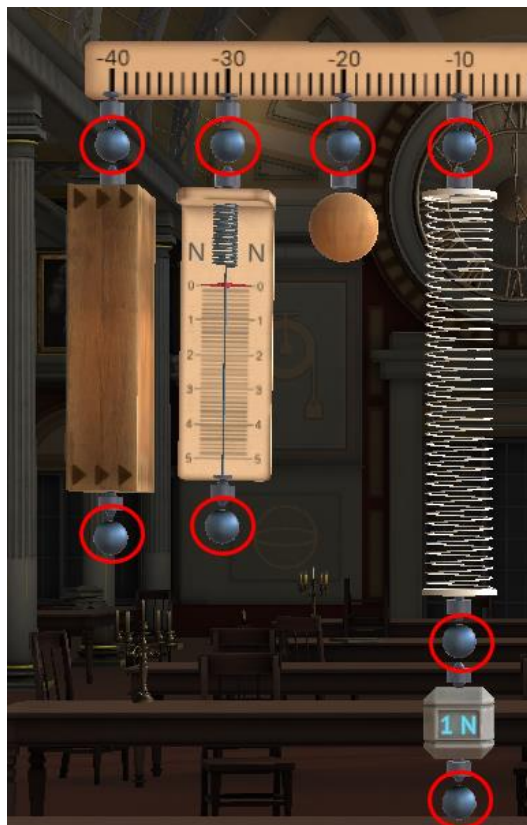


Figure 25 – Magnetic connectors on objects

To connect objects via magnetic connectors, move one of the objects to a position where the connectors are as close to each other as possible or intersect (Figure 26). If necessary, rotate the object with the mouse wheel.

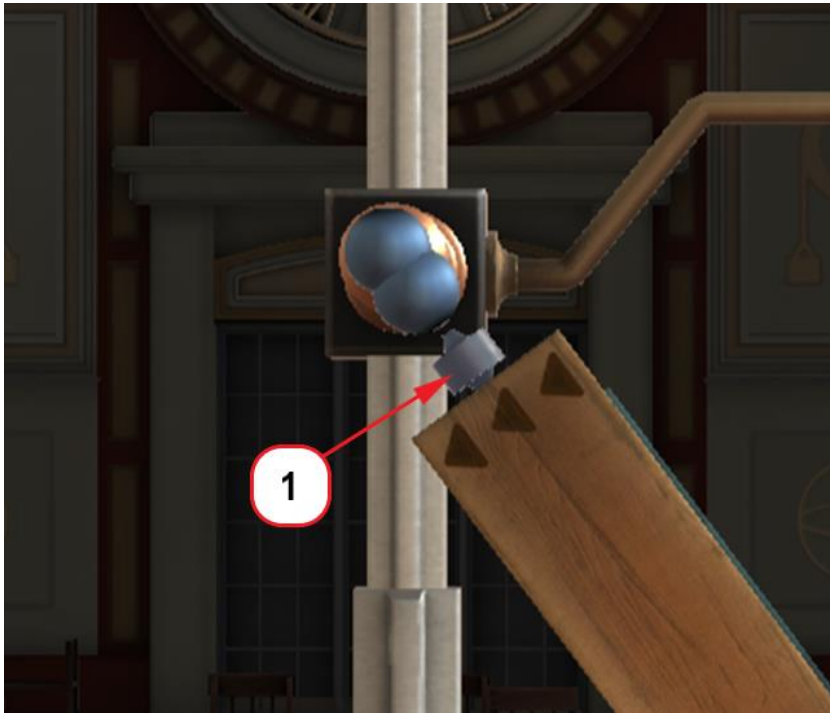


Figure 26 – Crossing magnetic object connectors



Figure 27 – Example of connecting objects

You can connect multiple objects at a single point; you can also create chains of connected objects (Figure 27).

To disengage the magnetic connectors, pull the base of the connector (1 in Figure 26) or the object itself until the connectors disengage.

10.5 Receiving and transmitting signals

A transmitter is a unit for receiving and transmitting radio signals on the principle of a walkie-talkie.

Transmitters can be used to set up remote start or stop operation of some instruments and meters. There may be multiple transmitters on one object; each transmitter triggers a function associated with that transmitter. For example, you can activate the stopwatch start on the signal from the inclined plane stop button and stop the countdown on the signal from the touch detector.

Two types of transmitters are used in the application:

- dual-channel: receive and send signals (Figure 28);
- single-channel: only send signals (Figure 29).

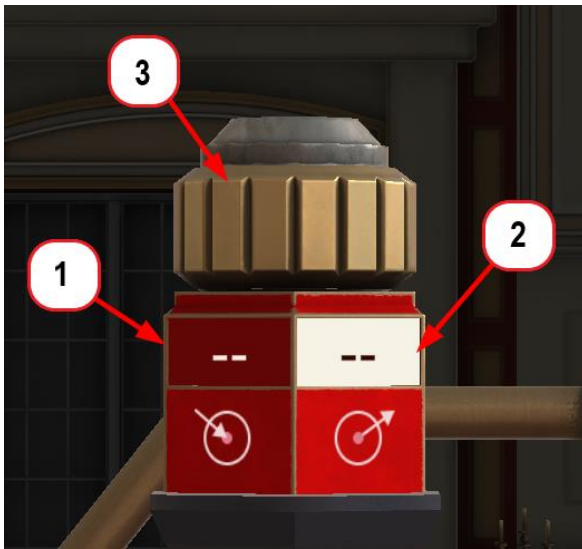


Figure 28 – Dual-channel transmitter

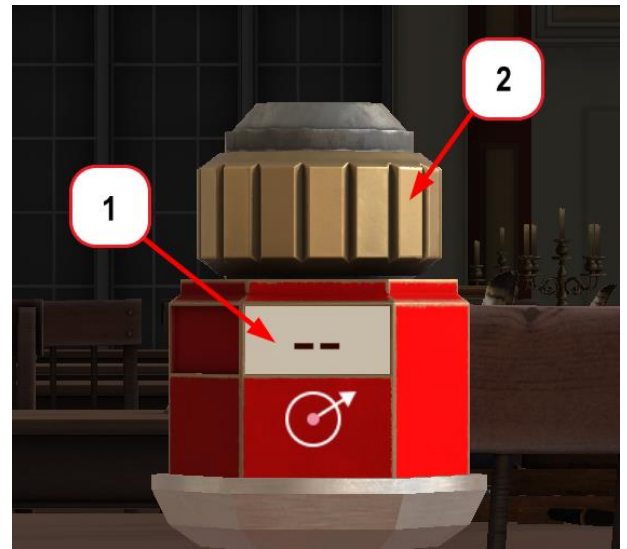


Figure 29 – Single-channel transmitter

The incoming channel (1 in 28) is responsible for receiving the signal from other instruments. The outgoing channel (2) sends a signal to other instruments. In order for the transmitters on the instruments to be able to collect and receive signals from each other; their channels must be tuned to the same frequency.

To tune the frequency of a transmitter channel (Figure 28), select the desired channel by pressing on it and rotate the tuning wheel (3) to the desired frequency value.

For example, to start the stopwatch by triggering the inclined plane stop (Figure 30), set the same frequency to the outgoing channel of the stop transmitter and the incoming channel of the stopwatch start button transmitter (1).

You can continue the experiment by setting the countdown to stop on the signal from the touch detector. To do this, set the same frequency to the outgoing channel of the touch detector and the incoming channel of the stopwatch stop button (2).

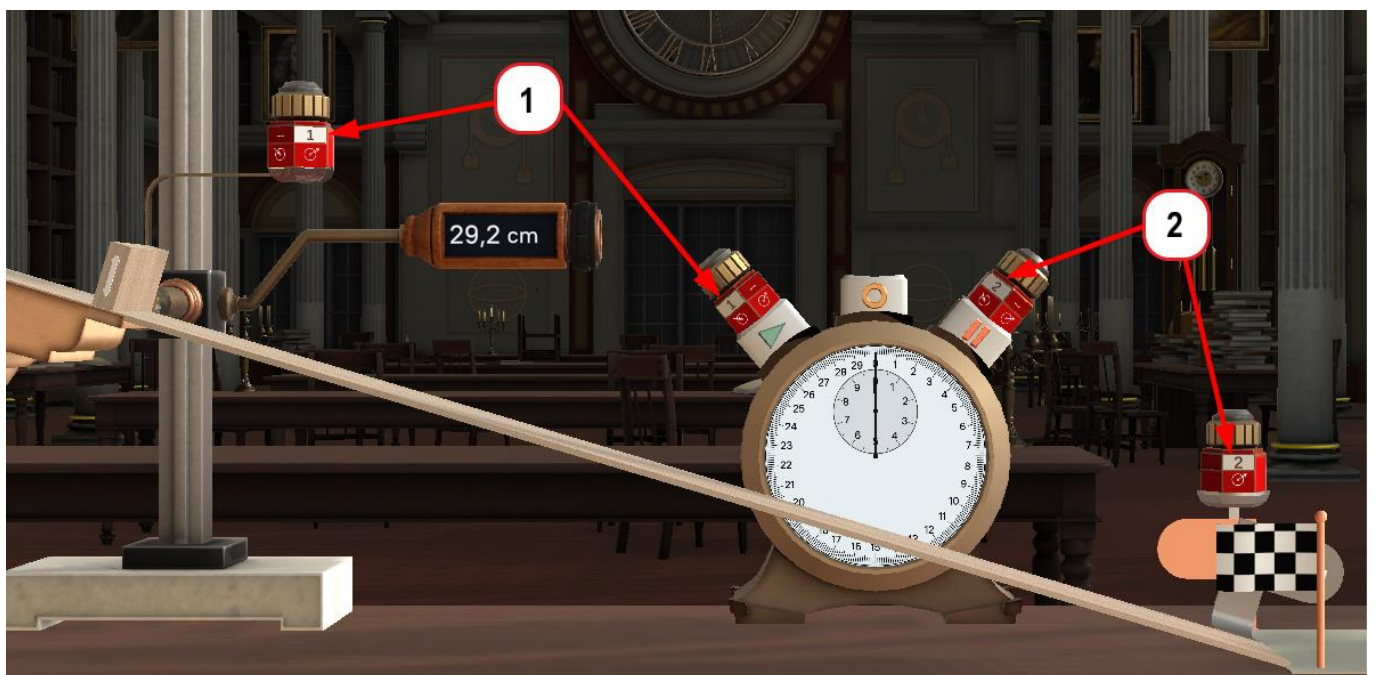


Figure 30 – Example of configuring transmitters

To cancel signal reception and transmission, set the channel frequency to "--".

10.6 Removing objects

To delete an object, hold it, drag it into one of the removal zones at the top of the workspace until the instrument image turns red and the open bin icon is displayed in the removal zone, and release (Figure 31).

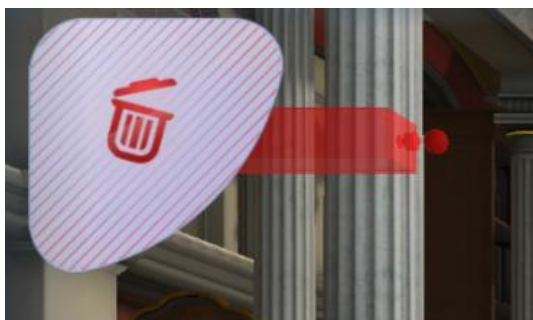


Figure 31 – Image of the instrument in the removal zone

If the object moves only along the desktop, also hold it down, drag the pointer to one of the removal zones, and release (Figure 32).

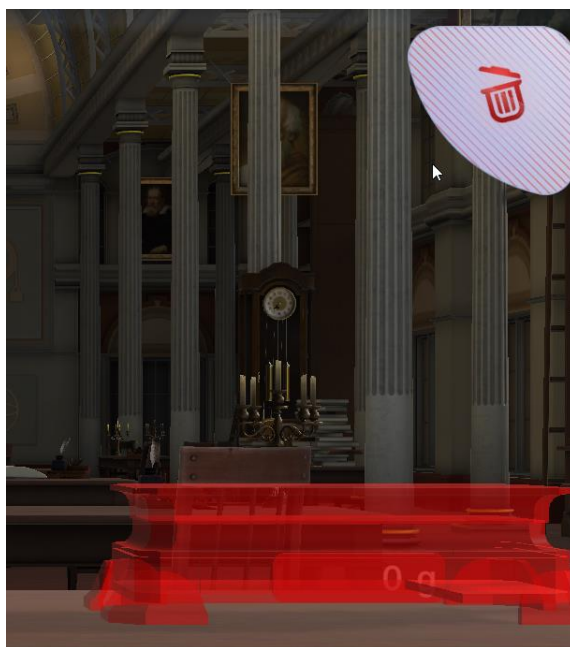


Figure 32 – Removing an object that moves only along the desktop

To remove all objects in the scene, use the **Clear Scene** button  on the control panel (see 5.1 “Clear Scene button”).

11 Describing the objects

11.1 Objects

11.1.1 A set of balls with sand

The set includes 5 transparent balls of equal capacity: one ball is empty, one ball is completely filled with dry sand, three more balls are filled with different amounts of sand. The balls are on a stand (Figure 34).

The set of balls can be moved by pulling the stand. You can also move each ball separately.



Figure 33 – Card of a set of balls with sand



Figure 34 – A set of balls with sand

11.1.2 Dividing wall

The dividing wall (Figure 36) is used as an obstacle on the desktop to keep objects (such as balls) from flying far away.

To change the height of the dividing wall, pull the handle (1).



Figure 35 – Dividing wall card

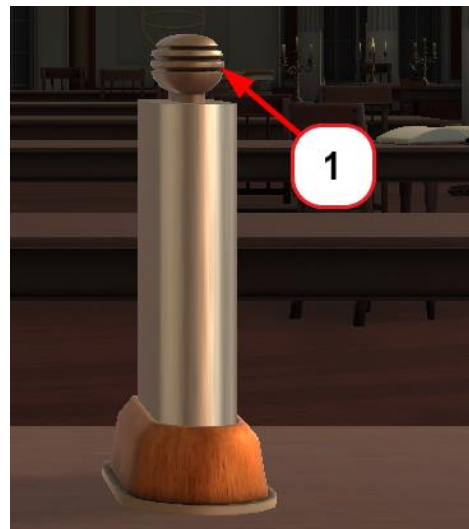


Figure 36 – Dividing wall

11.1.3 Ball

Ball is a ball-shaped object for conducting experiments.

To select the ball material, adjust its diameter and add an attachment before placing it in the scene, click the object card on the **Equipment** tab (Figure 37) and set the required values in the constructor (see 9.1 “Object constructor”).

The default values are set when the ball is created:

- material: aluminum;
- diameter: 6 cm;
- attachment: none.



Figure 37 – Ball card



Figure 38 – Ball

11.1.4 1 N weight

1 N weight is a weight with a weight of 1 N and a mass of 102 g for conducting experiments.



Figure 39 – 1 N weight card

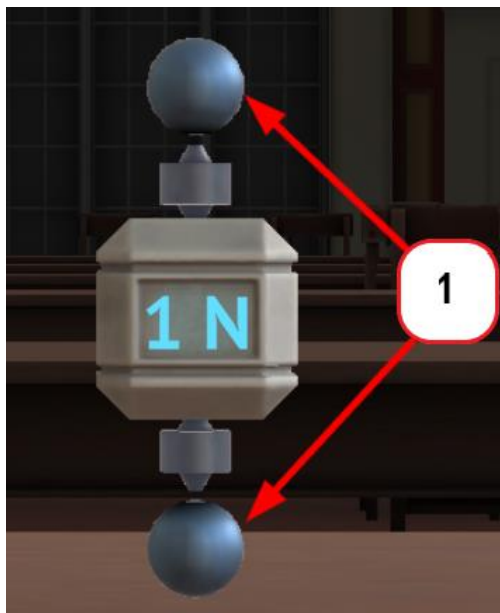


Figure 40 – 1 N weight

Use magnetic connectors (1 in Figure 40) to connect the object with other schematic elements (see 10.4 “Connecting objects using magnetic connectors”).

11.1.5 Parallelepiped

Parallelepiped is a parallelepiped-shaped object for conducting experiments.

To select material, adjust dimensions and add attachment before placing the parallelepiped in the scene, click the object card on the **Equipment** tab (Figure 41) and set the required values in the constructor (see 9.1 “Object constructor”).

The default values are set when the object is created:

- material: wood;
- length: 6 cm;

- height: 6 cm;
- width: 6 cm;
- attachment: none.



Figure 41 – Parallelepiped card



Figure 42 – Parallelepiped

11.1.6 Cylinder

Cylinder is a cylinder-shaped object for conducting experiments.

To select the material, adjust the dimensions and add attachment before placing the cylinder in the scene, click the object card on the **Equipment** tab (Figure 43) and set the required values in the constructor (see 9.1 “Object constructor”).

The default values are set when the object is created:

- material: wood;
- diameter: 6 cm;
- height: 6 cm;
- attachment: none.



Figure 43 – Cylinder card



Figure 44 – Cylinder

11.1.7 Letter V

The letter V is a tick-shaped object for conducting experiments.

To select the material, adjust the dimensions and add attachment before placing the letter V in the scene, click the object card on the **Equipment** tab (Figure 45) and set the required values in the constructor (see 9.1 “Object constructor”).

The default values are set when the object is created:

- material: aluminum;
- length: 6 cm;

- height: 6 cm;
- width: 6 cm;
- attachment: none.



Figure 45 – Letter V card



Figure 46 – Letter V

11.1.8 Wooden block



Figure 47 – Wooden block card

A wooden block is a parallelepiped-shaped object with sticky sides for conducting friction experiments.

The side faces of the block are equal in pairs (Figures 48 and 49). To turn the block over, click on the arrows at the edge of the block (1 in Figures 48 and 49). A wooden block cannot be turned over if another object is lying on it or there is not enough room to turn it over.

The two opposite side faces of the block have a sticky coating (3 in Figure 49) for better adhesion to other objects.

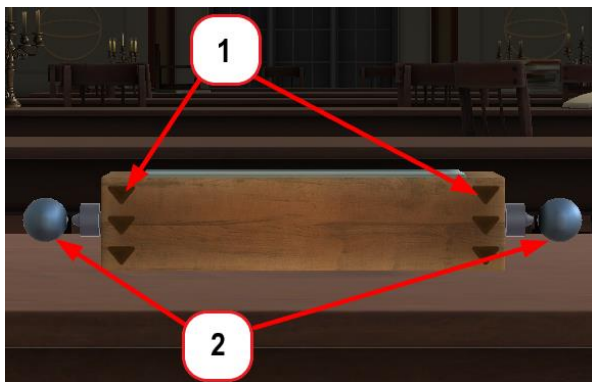


Figure 48 – Wooden block side

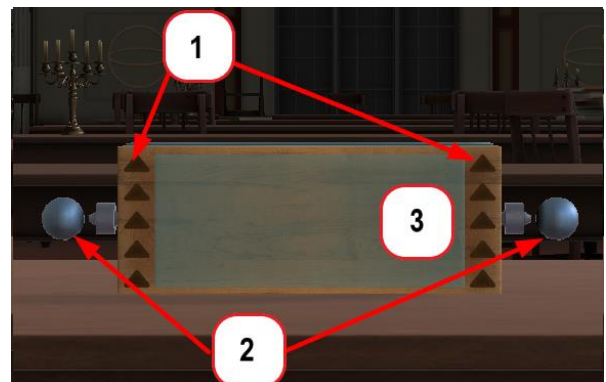


Figure 49 – Sticky block side

Use magnetic connectors (2) to connect the object with other schematic elements (see 10.4 “Connecting objects using magnetic connectors”).

11.1.9 Spring

A spring is an elastic object that stores potential energy.

To adjust the spring stiffness before placing it in the scene, click the object card on the **Equipment** tab (Figure 50) and set the desired value in the constructor (see item 9.1 “Object constructor”). The default setting when the instrument is created is 10 N/m.



Figure 50 – Spring card

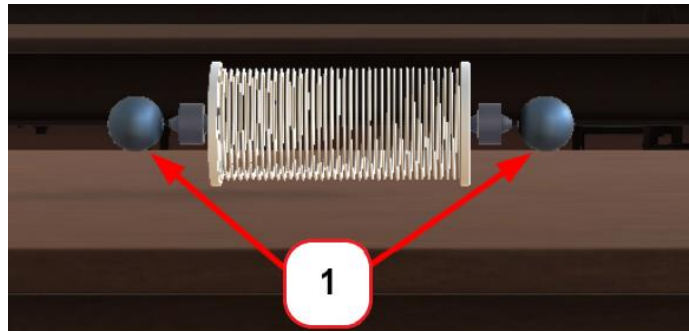


Figure 51 – Spring

Use magnetic connectors (1 in 51) to connect the object with other schematic elements (see 10.4 “Connecting objects using magnetic connectors”).

11.2 Instruments

11.2.1 Tripod

A tripod is a vertical stand for attaching objects.

To set the number of tripod holders before placing it in the scene, click the object card on the **Equipment** tab (Figure 52) and set the required value in the constructor (see 9.1 “Object constructor”).

By default, a tripod with one holder (Figure 53) will be created.



Figure 52 – Tripod card

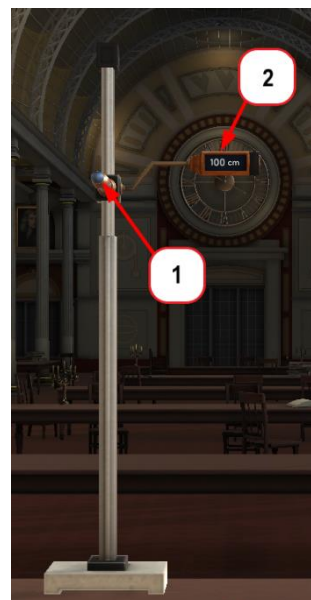


Figure 53 – Tripod

Use the magnetic connector (1) to attach objects to the tripod (see 10.4 “Connecting objects using magnetic connectors”).

To change the height of the connector, hold and pull the holder handle (2) up or down to the desired position. The set height value is displayed on the holder handle.

11.2.2 Spring pistol

A spring pistol is a mechanical device for transferring kinetic energy to an object.

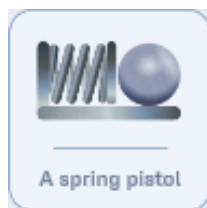


Figure 54 – Spring pistol card

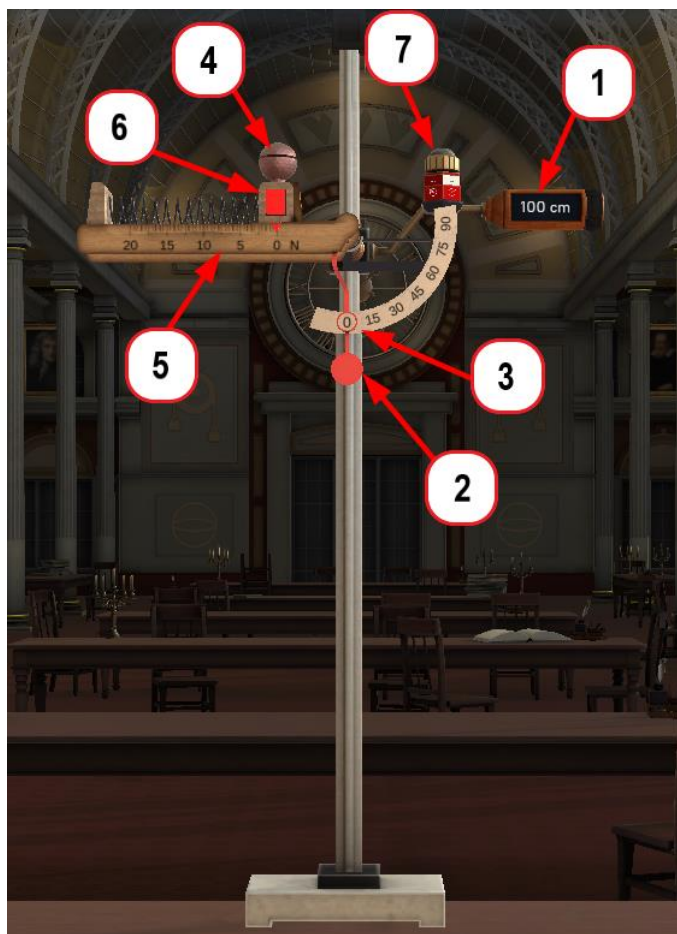


Figure 55 – Spring pistol

To change the height of the pistol on the tripod (Figure 55), hold and pull the holder handle (1) up or down to the desired position. The set height value is displayed on the holder handle.

To adjust the shot angle, pull the lever (2) to the right or left to the desired position. The set value (in degrees) is circled in red on the protractor (3). A value of “0” corresponds to a horizontal shot, a value of “90” — to a vertical shot.

To adjust the potential shot force, pull the cocking handle (4) to the left or right along the scale bar (5). The red arrow under the handle indicates the set value (in Newtons).

To fire a shot, adjust the shot force, place the object on the scale bar to the right of the cocking handle and press the button under the handle (6).

Use the transmitter (7) for remote activation of the instrument and communication with other objects in the scene (see 10.5 “Receiving and transmitting signals”).

11.2.3 Inclined plane

Inclined plane is a surface to create a slope.

To select the material of the inclined plane before placing it in the scene, click the object card on the Figure tab (Figure 56) and set the required value in the constructor (see 9.1 “Object constructor”).

By default, the instrument will be created with a wooden board (Figure 57).



Figure 56 – Inclined plane card

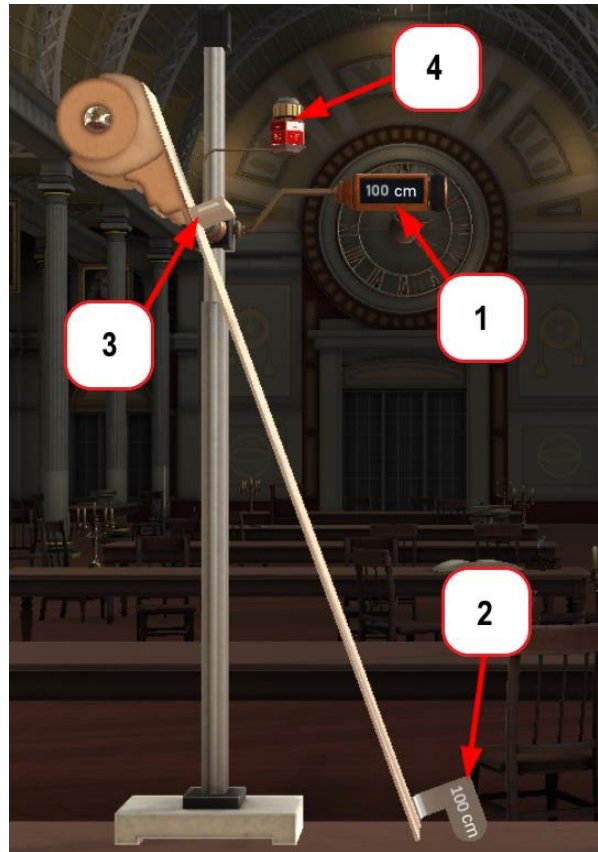


Figure 57 – Inclined plane

To change the height of the plane inclination, hold and pull the holder handle (1) up or down to the desired position. The set height value is displayed on the holder handle.

To change the length of the inclined plane, hold and pull the check mark at the bottom (2) up or down to the desired position. The set length value is displayed in the check mark.

In the left part of the inclined plane, there is an obstacle — stopper (3). To place an object on the plane, place it to the left of the closed stopper. Press the stopper to open or close it.

Use the transmitter (4) to remotely open and close the stopper and communicate with other objects in the scene (see 10.5 “Receiving and transmitting signals”).

11.2.4 Level fixator

A level fixator is a mechanism for holding objects at a certain height and releasing them into free fall.



Figure 58 – Level fixator card

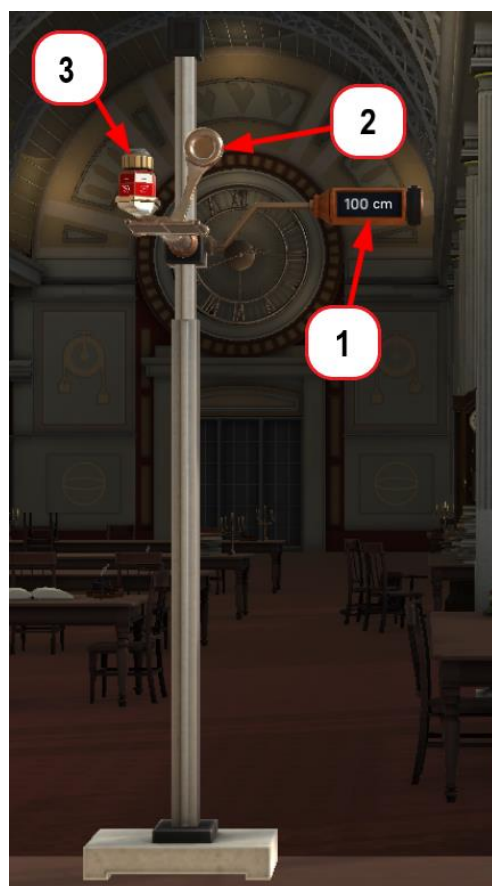


Figure 59 – Level fixator

To change the height of the clamp, hold and pull the holder handle (1) up or down to the desired position. The set height value is displayed on the holder handle.

Place the object on the plane under the lever (2). Press the lever or pull it to the right to release the item into free fall. Press the lever again or pull it to the left to close the retaining plane flaps.

Use the transmitter (3) for remote activation of the instrument and communication with other objects in the scene (see 10.5 “Receiving and transmitting signals”).

11.2.5 Newton's cradle

Newton's Cradle is a mechanical system to demonstrate the conversion of kinetic energy to potential energy and vice versa.

To set the number of balls before placing the instrument in the scene, click the object card on the **Equipment** tab (Figure 60) and set the required values in the constructor (see 9.1 “Object constructor”).

By default, an instrument with 5 balls will be created.



Figure 60 – Newton's cradle card

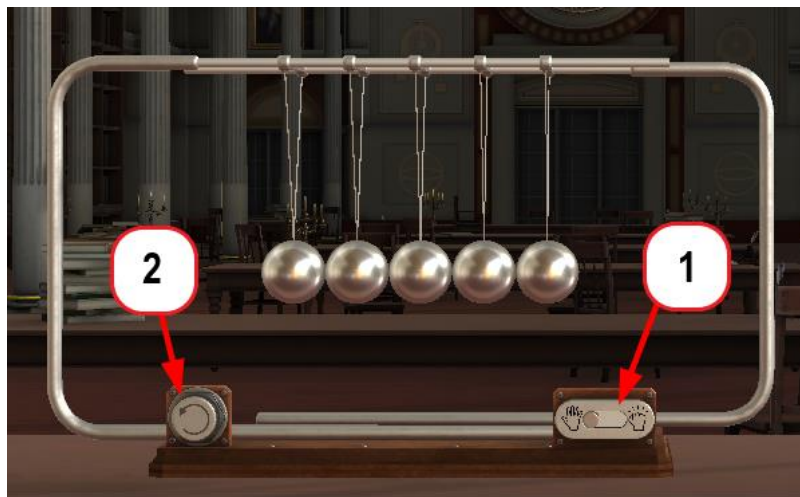


Figure 61 – Newton's cradle

To start the instrument (Figure 61), hold any of the balls, pull it to the side, and drop it.

Press the switch (1) to select the instrument operation mode:

- “Free move” mode . In this mode, the balls move freely and can be moved during operation.
- “Retention” mode . In this mode, the balls are fixed in the current state and can be placed in the desired positions.

Press the reset button (2) to bring the instrument back to its original state.

11.2.6 Ruler lever

A ruler lever is a ruler attached to a tripod with a zero mark in the center, at the point of attachment to the tripod. There are magnetic connectors on either side of the zero mark at the bottom of the ruler. The distance between the connectors is 10 cm, and the height of the tripod to the center of the ruler is 100 cm.

To add magnetic connectors at the top of the ruler lever before placing the instrument in the scene, click the object card in the **Equipment** tab (Figure 62) and set the desired value in the constructor (see 9.1 “Object constructor”).



Figure 62 – Ruler lever card

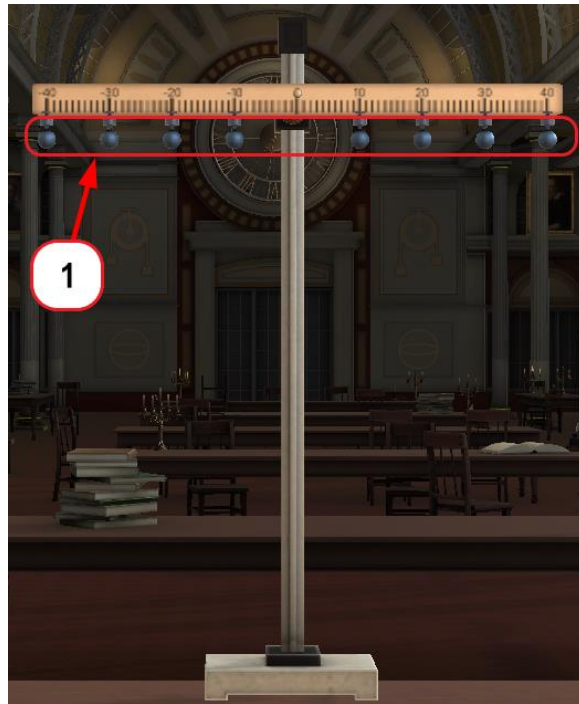


Figure 63 – Ruler lever

Use magnetic connectors (1) to attach objects to the ruler level (see 10.4 “Connecting objects using magnetic connectors”).

11.2.7 Thread pendulum

A thread pendulum is a steel ball suspended on a thread.

To set the ball mass before placing the instrument in the scene, click the object card on the **Equipment** tab (Figure 64) and set the required value in the constructor (see 9.1 “Object constructor”).

To adjust the thread length, press the knob (1 in Figure 65) and pull: up to increase the thread length, down to decrease it. The thread length is adjustable from 15 to 70 cm.

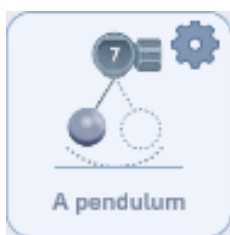


Figure 64 – Thread pendulum card

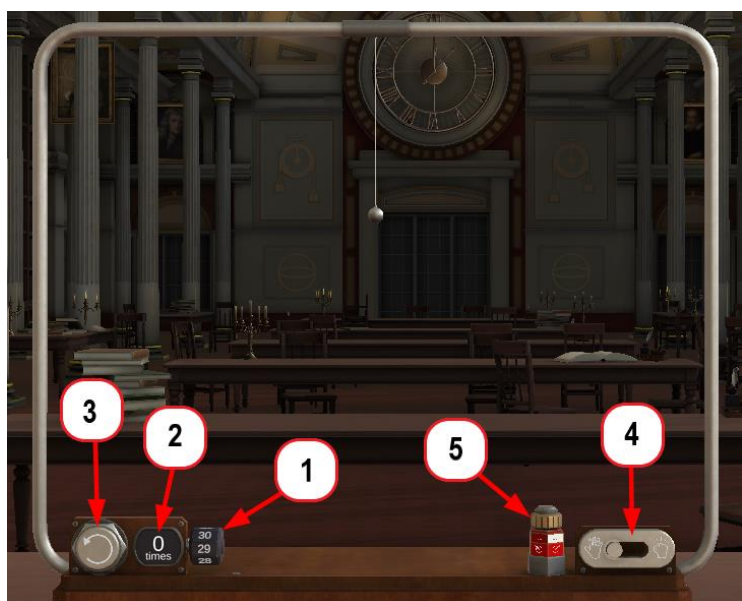


Figure 65 – Thread pendulum

To start the instrument (Figure 65), hold the ball, pull it to the side, and drop it. The screen (2) shows the number of oscillations of the pendulum. The oscillation count goes up to 99, then the screen constantly displays 99+. Press the screen to reset the counter to zero.

To reset the instrument, press the reset button (3).

Press the switch (4) to select the instrument operation mode:

- “Free move” mode . In this mode, the ball moves freely, they can be moved while the instrument is in operation.
- “Retention” mode . In this mode, the ball is fixed in its current state and can be moved to adjust the desired position.

Use the transmitter (5) to remotely start the instrument and communication with other objects in the scene (see 10.5 “Receiving and transmitting signals”).

11.2.8 Pulleys

Pulleys are mechanisms of several blocks placed on the stand, through which the threads pass.

There are 4 types of pulleys available in the application:

- Fixed pulley (see 11.2.8.1 “Fixed and movable pulleys”);
- Movable pulley (see 11.2.8.1 “Fixed and movable pulleys”);
- Block and tackle (see 11.2.8.2 “Block and tackle”);
- Rope and pulley system (see 11.2.8.3 “Rope and pulley system”).



In the Virtual Lab, the threads pulled from the pulleys are not deformed: they do not stretch or twist.

11.2.8.1 Fixed and movable pulleys

Fixed and movable pulleys are stands with two pulleys and threads. In the fixed pulley, the axes of the mechanisms are fixed; in the moving pulley, they are not.

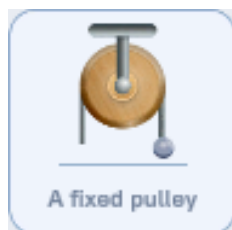


Figure 66 – Fixed pulley card



Figure 67 – Movable pulley card

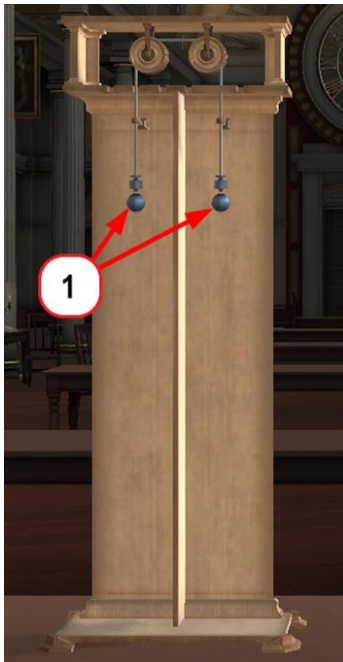


Figure 68 – Fixed pulley



Figure 69 – Movable pulley

Use magnetic connectors (1 in Figures 68 and 69) to attach objects to the pulleys (see 10.4 “Connecting objects using magnetic connectors”).

11.2.8.2 Block and tackle

Block and tackle — stand with three pulleys: one pulley is movable, two pulleys are fixed.

Use magnetic connectors (1 in Figure 71) to attach objects to the pulleys (see 10.4 “Connecting objects using magnetic connectors”).



Figure 70 – Block and tackle card

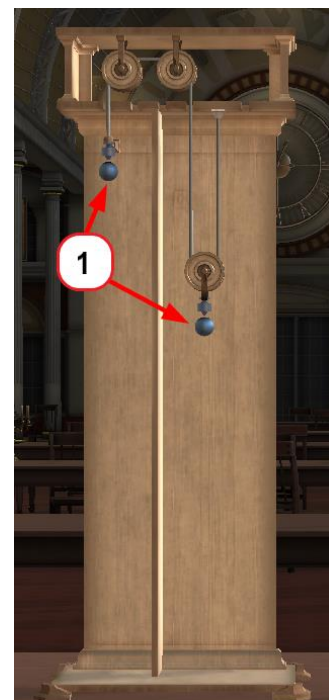


Figure 71 – Block and tackle

11.2.8.3 Rope and pulley system

Rope and pulley system — stand with four pulleys: one pulley is movable, three pulleys are fixed.

To set the number of blocks on the movable and fixed pulleys before placing the instrument in the scene, click the object card on the **Equipment** tab (Figure 72) and set the required value in the constructor (see 9.1 “Object constructor”). By default, a stand with two blocks will be created.

Use magnetic connectors (1 in 73) to attach objects to the pulleys (see 10.4 “Connecting objects using magnetic connectors”).



Figure 72 – Rope and pulley system card

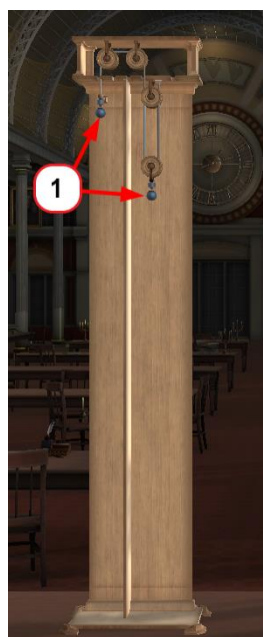


Figure 73 – Rope and pulley system

11.2.9 Two-sided board

Two-sided board is a board with sides made of different materials. The bottom of the board is sticky; it secures the board to the desktop.

To select the material of the top part of the board before placing it in the scene, click the object card on the **Equipment** tab (Figure 74) and set the required value in the constructor (see 9.1 “Object constructor”). By default, a board with a wooden surface will be created.



Figure 74 – Two-sided board card



Figure 75 – Two-sided board

11.3 Meters

11.3.1 Measuring container

Measuring container is a glass container located on the scales. Scales measure the total weight of the liquid and objects in the container. The mass of the container itself and the pressure on it are not considered.

To customize the size, capacity, and content of the container and to select the liquid before placing the measuring container in the scene, click the object card on the **Equipment** tab (Figure 76) and set the values in the constructor (see 9.1 “Object constructor”). The default values are set when the instrument is created:

- width: 7 cm;
- depth: 7 cm;
- height: 13 cm;
- capacity: 637 ml;
- content: 50 %;
- liquid: water.

A 20% salt solution (density 1.148 g/mL) is used to fill the container.



Figure 76 – Measuring container card



Figure 77 – Measuring container

To place an object in a container, drag it into the container and drop it.

The measuring container must not be moved around the desktop when an object is placed in it.

11.3.2 Digital scales

Digital scales are an instrument for measuring the mass of bodies.

To weigh an object, place it on the measuring surface. The weight will be displayed on the instrument screen.

The maximum load of the scales is 9999.9 g. When the maximum load is exceeded, “9999.9+“ is displayed on the instrument screen.



Figure 78 – Digital scales card



Figure 79 – Digital scales

11.3.3 Stopwatch

A stopwatch is an instrument for measuring periods of time.

The stopwatch has two dials (Figure 81): seconds (1) and minutes (2). The division value of the seconds dial is 0.1 s, the minute dial is 0.5 min. The measurement time is up to 10 minutes.

Press the button (3) to start the countdown. To stop the countdown, press the button (4). Press button (5) to reset the stopwatch.

Use the transmitter (6) to start the stopwatch remotely and the transmitter (7) to stop it remotely (see 10.5 “Receiving and transmitting signals”).



Figure 80 – Stopwatch card

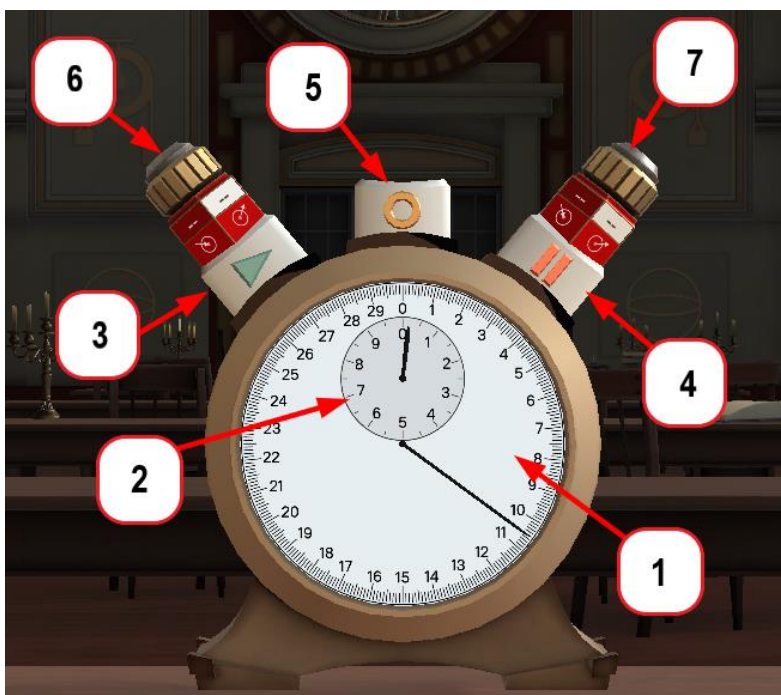


Figure 81 – Stopwatch

11.3.4 Touch detector



Figure 82 – Touch detector card

A touch detector is an instrument for recording the point and moment when its surface is touched by another object.

To change the surface area of the detector (Figures 83 and 84), pull the instrument shutter (1) to the left or right.

The check mark (2) records where an object touches the detector surface (Figure 84). Until the first touch, the check mark is opposite the transmitter (Figure 83).

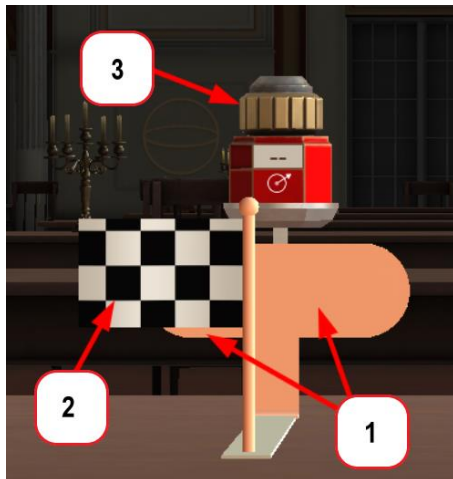


Figure 83 – Touch detector before the first interaction with an item

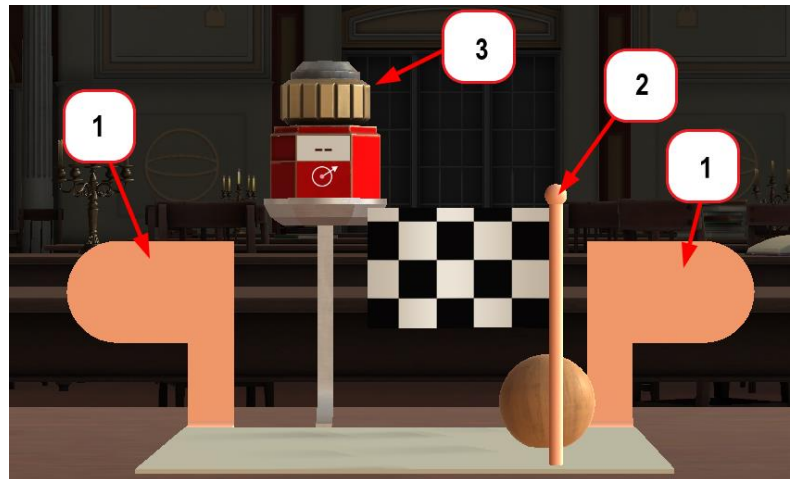


Figure 84 – Touch point locking

Use the transmitter (3) to transmit detector data to other instruments (see 10.5 “Receiving and transmitting signals”). The touch detector transmitter has an outgoing channel only.

11.3.5 Dynamometer

A dynamometer is an instrument for measuring force.

To customize the measurement range or hide the instrument scale before placing it in the scene, click the object card on the **Equipment** tab (Figure 85) and set the values in the constructor (see 9.1 “Object constructor”). The default values are set when the instrument is created:

- measuring range: 5 H;
- hide scale: no.

On an instrument with a hidden scale (Figure 87), you can make marks with the **Lines** tool (see 6.2 “Lines”) and erase them with the **Eraser** tool (see 6.3 “Eraser”).



Figure 85 – Dynamometer card

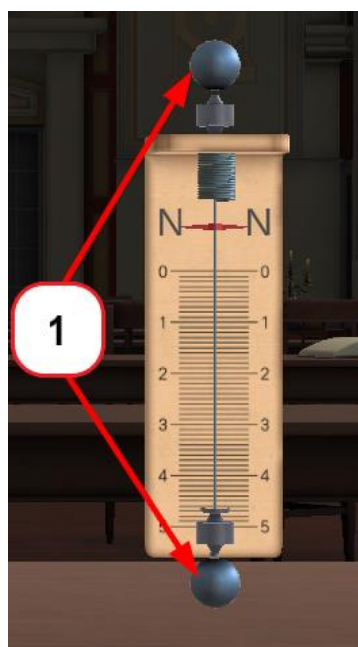


Figure 86 – Dynamometer with scale

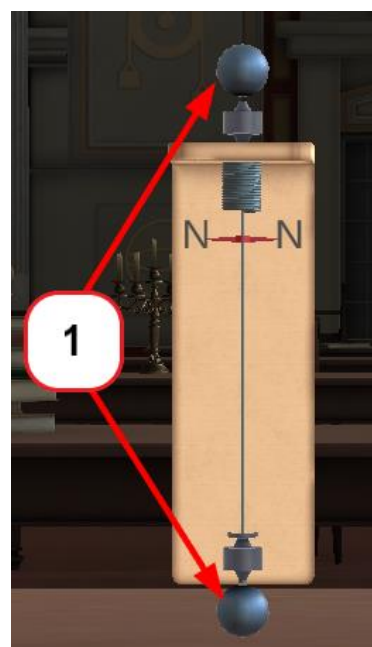


Figure 87 – Динамометр without scale

Use magnetic connectors (1) to connect the dynamometer to other objects (see 10.4 “Connecting objects using magnetic connectors”).

11.3.6 Height detector

Height detector is an instrument for measuring the distance from the desktop to objects above the instrument.

To measure the distance from the desktop to an object, place the object in an area above the detector (e.g., on a height lock). The height is measured to the lowest point of the object. The instrument screen (1 in the figure) shows the last maximum value.

To reset the detector, press the button (2).

The detector determines the location height only for small bodies: a ball, a parallelepiped, a cylinder, a letter V, a ball with sand, and a 1 N weight.



Figure 88 – Height detector card

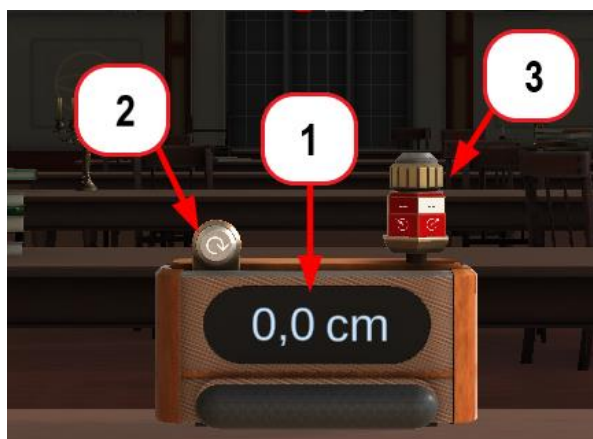


Figure 89 – Height detector

Use the transmitter (3) to transmit instrument data and communicate with other objects in the scene (see 10.5 “Receiving and transmitting signals”).