



Virtual Laboratory



PHYSICS

Optics

User
Manual



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Terms and Definitions

Term	Definition
Virtual Laboratory	Application "Virtual Laboratory "Physics", section "Optics"
Camera	A stage tool that allows the user to observe everything happening in the Virtual Laboratory
Click	An action. To click: – when using a mouse, move the mouse pointer to the object, press and release the left mouse button without moving the pointer; – when using a touchscreen, press the object with a finger and release without moving the finger along the screen.
Toggle Button	A button that changes its state from inactive to active and vice versa after being pressed. The state is retained until the next interaction
Optical Axis	A line starting at the point of light emission from the light source, running parallel to the optical bench to its opposite end. It passes through the centers of all objects on the bench
Optical Bench	An object used in optical experiments. The bench serves as a guide line for setting up objects from the equipment library and indirectly indicates the optical axis
Working Area	A part of the scene where the user can interact with the available objects of the Virtual Laboratory
Scene	A virtual three-dimensional space within which the user can interact with the Virtual Laboratory objects. The concept of "scene" also includes the data of the current research (positions of objects, their parameters, etc.)

1 System requirements

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

- **Processor:** Intel Ivy Bridge series / AMD Bulldozer series or newer.
- **RAM:** 4 GB or more.
- **Graphics Card:**
 - Integrated: Intel HD Graphics 5000 / Intel Iris or newer;
 - Discrete: GeForce 400 series or newer / Radeon HD 7000 series or newer.
- **Screen Resolution:** 1920x1080 / 1920x1200 and higher (4K and Retina displays require a more powerful graphics card for comfortable operation).
- **Supported Browsers:** Chrome, Yandex.Browser, Opera 44+, Firefox 51+, Edge 79+, Safari 15+.
- **Supported Operating Systems:** Microsoft Windows 7 (x64 versions) 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 Interface of the application

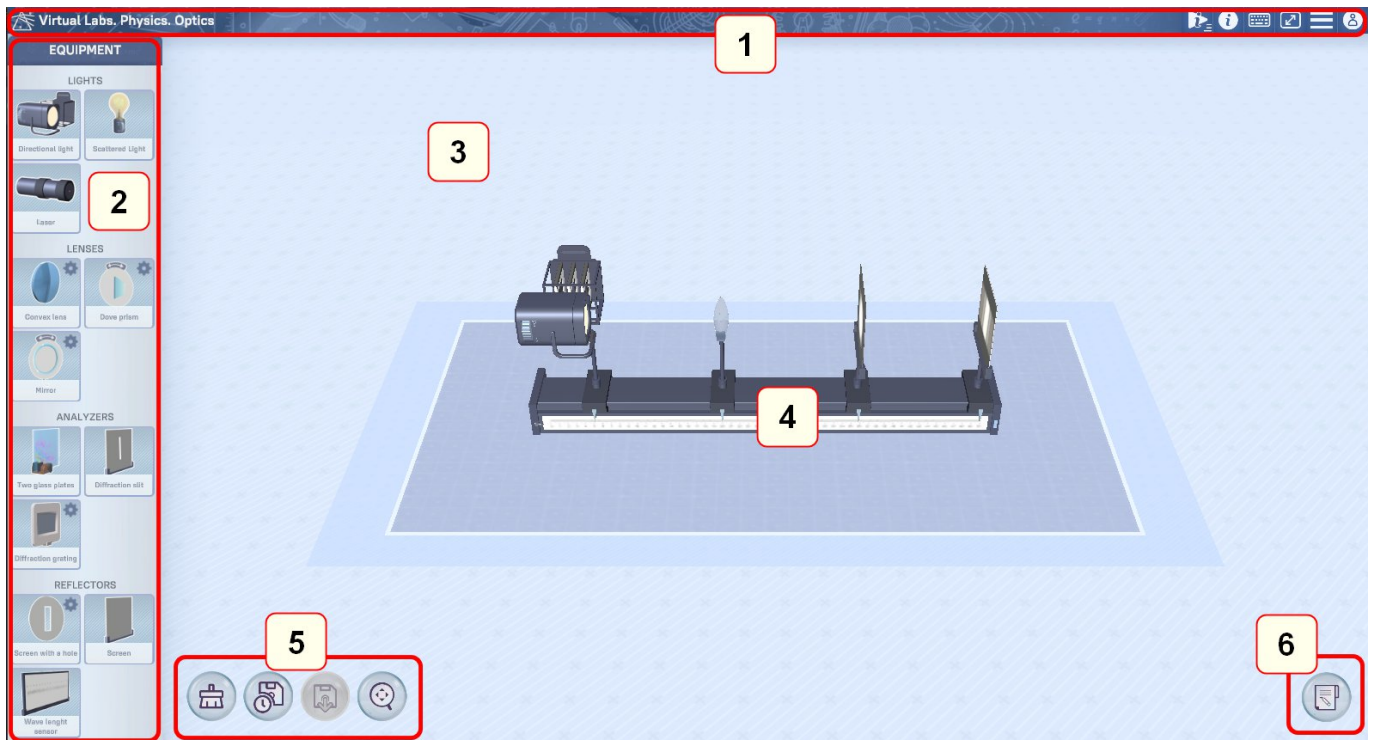


Figure 1 – The Interface of the Virtual Laboratory "Physics", section "Optics"

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

- 1) **the Application Header panel** contains the logo and name of the Virtual Laboratory (on the left) and a set of functional buttons (on the right) (see [3 Application Header panel](#));
- 2) **the Equipment panel** contains cards of objects that can be created in the scene (see [7 Equipment panel](#));
- 3) **working Area** is a part of the scene where you can create items from the list of available equipment, interact with them, and navigate using the camera;
- 4) **the Optical bench**: A platform in the workspace of the virtual laboratory where various optical components and equipment can be placed and interacted with;
- 5) **the control panel** contains buttons for controlling the Virtual Laboratory scene (see [6 Control panel](#));
- 6) **Scene Card button**  (see [4 Scene Card](#)).

3 Application Header panel

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



Figure 2 – Functional buttons of the Application Header panel

- button to open the Virtual Laboratory instructions  (see [3.1 Instruction](#));
- button to turn on/off the Tips mode  (see [3.2 Tips mode](#));
- button to turn on/off the Virtual Keyboard mode  (see [3.3 Virtual Keyboard](#));
- button to turn on/off the Fullscreen mode  (see [3.4 Fullscreen mode](#));
- button to open scene dropdown menu  (see [3.5 Scene Interaction Menu](#));
- user menu button  (see [3.6 User profile](#)).

3.1 Instruction

To select an instruction to view, click the **Instructions** toggle-button  in the **Application Header** panel. A menu will open from which you can select a video instruction or a user manual (Figure 3).

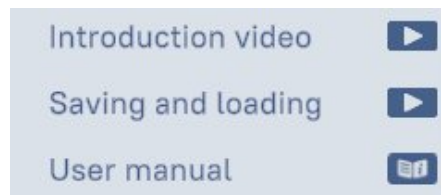


Figure 3 – Instruction selection menu

The video instruction **Introducing video** allows you to get an idea of the main capabilities of the Virtual Laboratory and how to work with the tools; the video instruction **Saving and loading** provides information on saving and loading the scenes. Video instructions play in a window that opens over the scene. You can control the playback by using the built-in player (Figure 4).

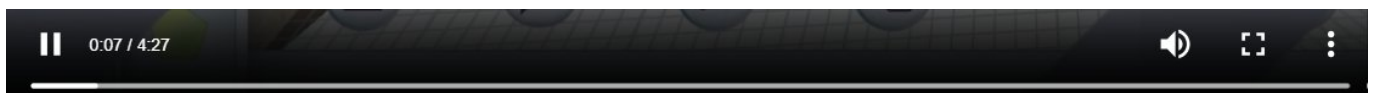


Figure 4 – Player control elements

To close the playback screen, click the **Close** button  in the top right corner of the screen. The **User manual** opens as a PDF in a new browser tab.

3.2 Tips mode

Press the **Tips** toggle-button  on the **Application Header** panel to switch to Interactive Tips mode. Tip points will appear near the objects in the scene. To view a tip, press the point next to the object (Figure 5).

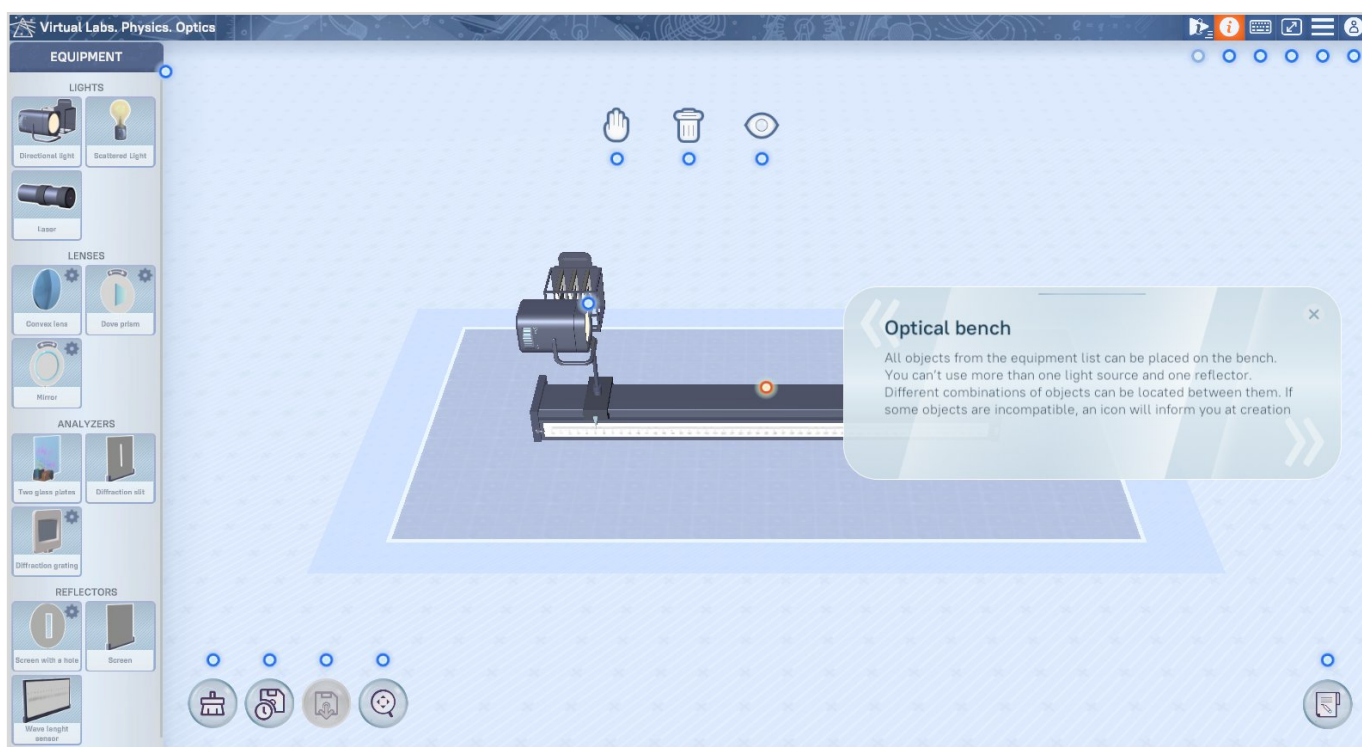


Figure 5 – Tips mode

To close the tip panel, press the tip-point again or click on the cross in the upper right corner of the panel (Figure 5). The tip will also close if you open another tip.

Tip points change their outline color depending on whether the user has viewed the tip (Figure 6):

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

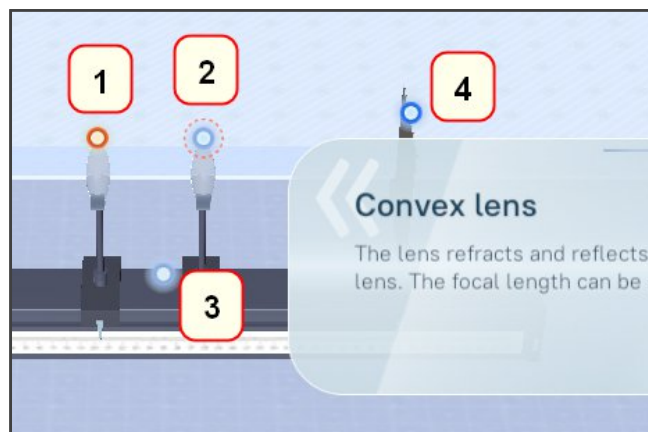


Figure 6 – Different outline colours for tip points

In addition, there are three hidden tip icons in the Virtual Laboratory: **Moving Objects**, **Deleting Objects**, **Navigating the Scene** (Figure 7). They are only visible in tip mode.



Figure 7 – Hidden tip icons

To exit the tip mode, press the button  on the **Application Header** panel.

3.3 Virtual Keyboard

To be able to use the Virtual Keyboard, press the toggle button  on the **Application Header** panel. In this mode, a Virtual Keyboard is displayed on the screen after clicking on the text fields in the scene card (Figure 8).



Figure 8 – Virtual Keyboard

The Virtual Keyboard has three layouts: Cyrillic and symbolic. The layout is changed using the button  on the Virtual Keyboard.

To exit the Virtual Keyboard mode, press the button  on the **Application Header** panel.

3.4 Fullscreen mode

To enable full screen mode, press the **Fullscreen** button  on the **Application Header** panel. The application will expand to full screen, hiding the browser frame and the OS taskbar. To exit Fullscreen mode, press the button  again or press the **Esc** button.

3.5 Scene Interaction Menu

While working in the Virtual Laboratory, you can:

- save the current scene (see [3.5.1 Saving the scene](#));
- save a copy of the current scene (see [3.5.2 Saving a 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](#)).

All these actions can be performed using the drop-down scene work menu. The menu opens when you press the button  on the **Application Header** panel (Figure 9).

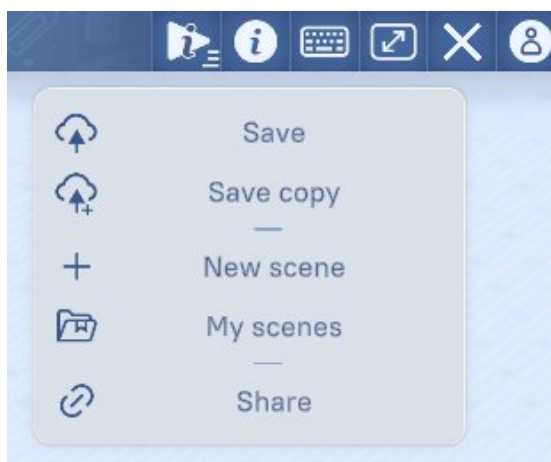


Figure 9 – Drop-down scene work menu

To close the menu, press the button  or any free scene area.

3.5.1 Saving the scene

To save the scene to the **My scenes** library, select **Save** in the drop-down menu (Figure 9). If this scene has never been saved before, the saving window will be opened (Figure 10).

Figure 10 – Scene saving form

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

If the **Scene name** and **Scene description** fields were filled in in the scene card, then these values will be displayed when saving the scene (see [4 Scene Card](#)).

You can use the Virtual Keyboard if necessary. To do so, use the button , located to the left of the saving form. This button duplicates the button  in the **Application Header** panel (see [3.3 Virtual Keyboard](#)): if the **Application Header** had the Virtual Keyboard mode enabled, then the button next to the scene saving form will also be in the active state  and vice versa.

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

3.5.2 Saving a scene copy

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

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

If the scene has already been saved, the previously saved scene name with the copy number in brackets will be displayed in the **Scene name** field — **Scene 1(3)**. The scene name and copy number can be adjusted or left unchanged.

If the **Scene name** and **Scene description** fields were filled in in the scene card, then this data will be displayed when saving a copy of the scene (see [4 Scene Card](#)).

Click the  button to save a copy of the scene.

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

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

3.5.3 Creating a new scene

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

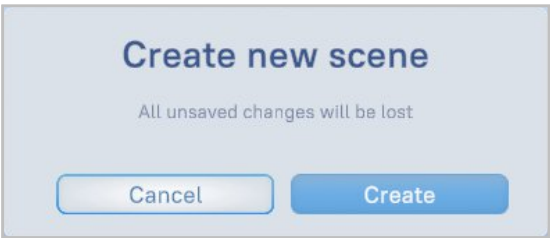


Figure 11 – Create New Scene window

To avoid losing current data, click the  button and continue working with the scene. If you do not need to save the data, click the  button after which 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 scenes, select **My scenes** in the drop-down menu (Figure 9). The **My scenes** library page will open (Figure 12).

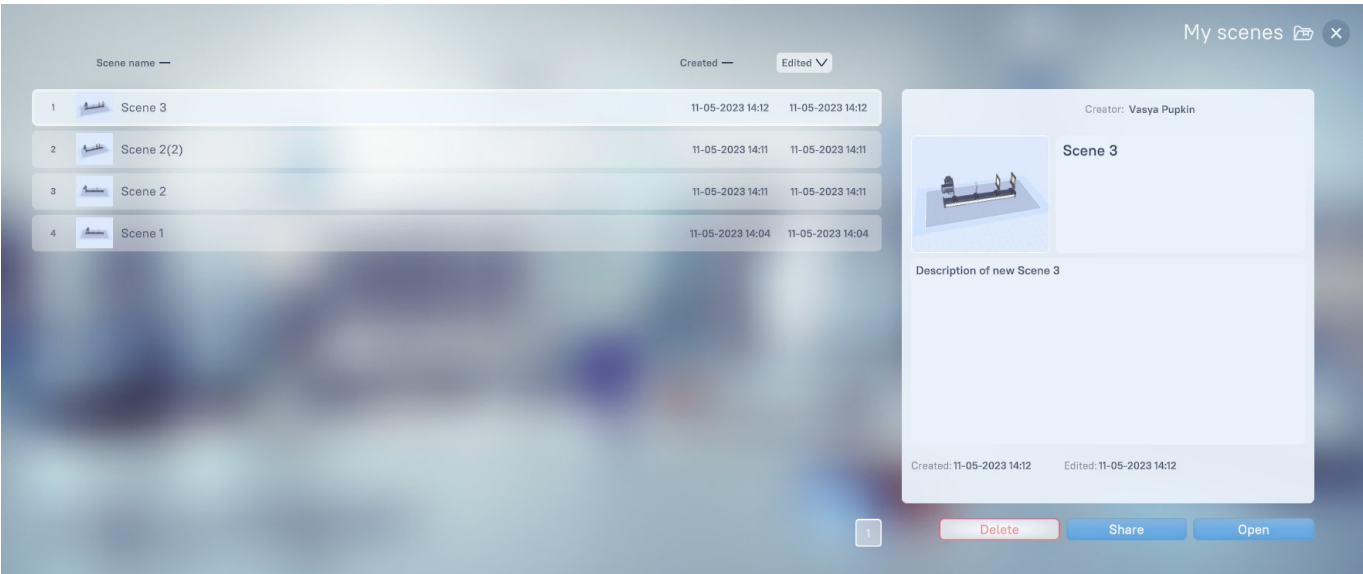


Figure 12 – My scenes library

On the left side of the screen, a list of all saved scenes will be displayed. You can sort the data by scene name, creation date, and modification date. To sort, click on the name of the corresponding table

column (**Name**, **Created** or **Modified**). The "-" icon next to the name will change to a check mark,

indicating the sorting direction .

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

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

3.5.5 Saving a link to a scene

To share a link to the current scene, select **Share** in the drop-down menu (Figure 9). The link will be copied to the clipboard, and you can save or share it. At this point, the scene needs to be saved, and if you have not yet saved this scene, the save form (Figure 10) will appear. You can save the link from the clipboard or send it to someone.

3.6 User profile

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



Figure 13 – User Menu

When you select **Profile** in the menu, you can view your profile data in a new browser tab.

When you select **Switch user**, two buttons appear under the menu: press , to change the current account, or , to continue working under the current account.

To close the menu, press the button  or click anywhere else on the scene.

4 Scene Card

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

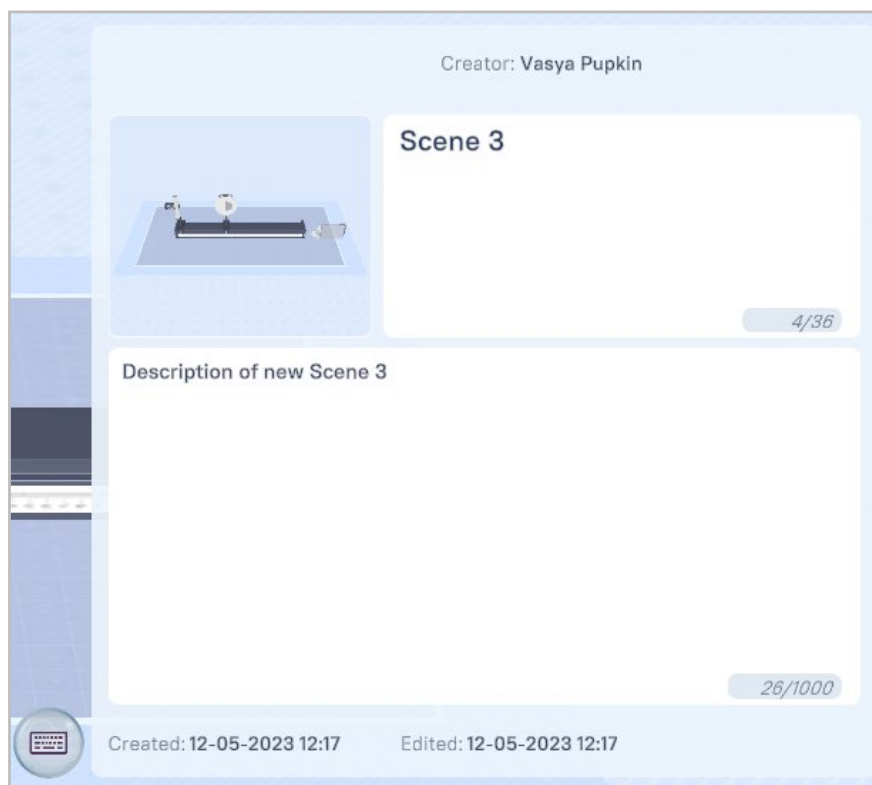
The screenshot shows a 'Scene Card' for 'Scene 3'. At the top, it says 'Creator: Vasya Pupkin'. Below this is a small 3D scene preview showing a table with objects on it. To the right of the preview is the title 'Scene 3' and a character count '4/36'. Below the preview is a large text area titled 'Description of new Scene 3' with a character count '26/1000'. At the bottom, it shows 'Created: 12-05-2023 12:17' and 'Edited: 12-05-2023 12:17'. There is a small icon in the bottom left corner.

Figure 14 – Scene card

Scene cards is opened:

- when you click on the **Scene Card** button  (Figure 1);
- when saving a scene or a copy of it (see [3.5.1 Saving the scene](#) и [3.5.2 Saving a scene copy](#));
- when selecting 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 the scene card;
- you have already saved the scene or a copy of it;
- you opened a scene with a filled in card using a link from another user;
- you have opened a public scene with a filled in card.

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

Information on the card can be edited and deleted. You can use your device's keyboard or the Virtual Keyboard to fill in or edit the **Scene name** and **Scene description** fields. For more information about using the Virtual Keyboard, see [3.3 Virtual Keyboard](#) and [3.5.1 Saving the scene](#).

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

5 Camera

The camera is a scene tool that allows you to observe everything happening in the Virtual Laboratory.

When the application is loaded, the camera is in the default position — perpendicular to the center of the bench at some distance. At any moment, you can quickly return the camera to this position using the

Full Scene button .

The camera can move along a semicircle around the focus point. The focus point can only move along the optical axis and cannot go beyond the optical bench.

To rotate the camera around the focus point, press the left mouse button (or two fingers when using a touch screen) anywhere on the scene except objects and the optical axis, and without releasing, drag the pointer to the left (for counter-clockwise rotation) or to the right (for clockwise rotation).

To move the camera, press the right or middle (wheel) mouse button (or one finger when using a touch screen) at any point on the scene, and without releasing, pull the pointer in the desired direction. In this case, the camera's focus point will move along the optical axis. Visually, the direction of the scene movement coincides with the direction of the pointer movement vector projection onto the optical axis line. If the pointer moves perpendicular to the bench, nothing happens.

To focus the camera on an object placed on the optical bench, click the left mouse button (or finger when using a touch screen) on this object.

To zoom in the camera, rotate the mouse wheel away from you or when using a touch screen, touch the screen with two fingers and spread them apart.

To zoom out the camera, rotate the mouse wheel towards you or when using a touch screen, touch the screen with two fingers and bring them together.

6 Control panel

Scene control panel (Figure 15) contains buttons that help you clear the scene, save and load the state of the scene, or return the camera to the default position.



Figure 15 – Control panel

6.1 Clear Scene button

The **Clear Scene** button  is available if at least one object is placed on the optical bench. When you click on the button, a confirmation window is opened (Figure 16).

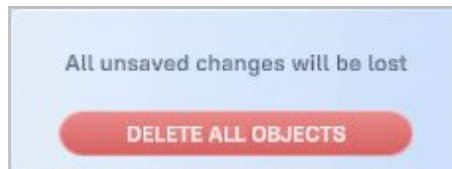


Figure 16 – Confirmation window to clear the scene

Click the **Delete all objects** button to clear the scene. Click anywhere on the screen outside the window to cancel the action if you don't want to delete all objects.

6.2 Save Point button

A save point is a fixed state of the scene. To create a save point, click the button . The application will then save the settings of the objects and their location on the optical bench.

The **Save Point** button  is available if at least one object is placed on the optical bench. You can only save one state of the scene. Pressing the button again overwrites the previous state.

6.3 Return to Save Point Button

The **Return to Save Point** button  is not available until a save point is created . Pressing the button  returns the scene to the state recorded at the time of the last press of the **Save Point** button. This action deselects the object.

6.4 Full Scene button

When you click the **Full Scene** button  the camera moves to the default position — so that the entire scene is displayed.

7 Equipment panel



Figure 17 – Equipment Panel

The **Equipment** panel (Figure 17) contains cards of objects available to the user. The cards are divided into four groups:

- light sources;
- lenses;
- spectral devices;
- reflectors.

Each card contains an icon of the device and its name. A constructor is provided (icon ) , for some objects. It allows the user to edit the settings of the device before placing it on the optical bench.

When you click on an object card (1 in Figure 18), the card is activated: an info panel with a description of the selected object is displayed (2), and if the object has a constructor, the constructor panel appears (3).

The info panel and constructor will be hidden with a repeated click on an object card.

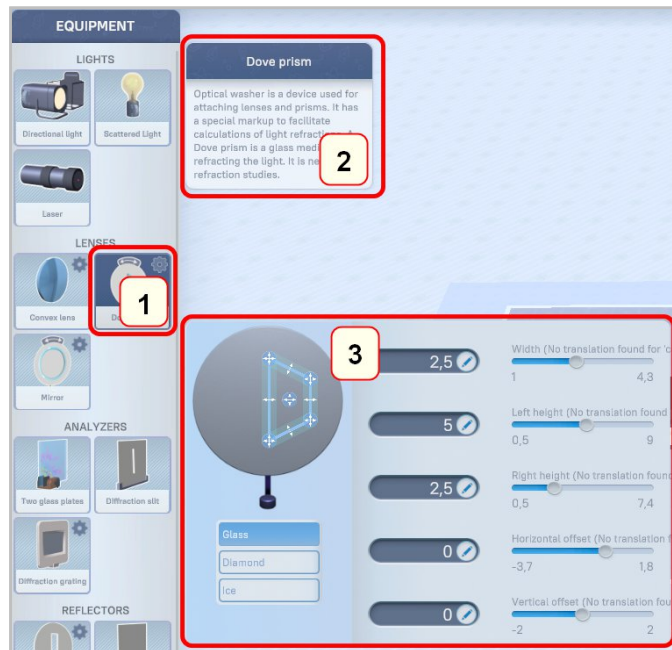


Figure 18 – Activating an object card

7.1 Object constructor

The object constructor (Figure 19) is designed to set the parameters of an object before placing it on the optical bench.



Figure 19 – Object Constructor

The set of parameters depends on the selected object:

- Some parameters have a fixed set of options (1). You need to choose one option from the list.
- Some parameters have a range of values. For these parameters, there is a panel displaying the current value (2), a numpad call button , a slider and a slider knob (3). You can set a new value for the parameter in one of the following ways:
 - click in the slider zone;
 - drag the slider knob;
 - press the button and set the exact value of the parameter on the numpad (see [7.2 Numpad](#)).

- If the parameter has a fixed value of "Yes/No" (4) (for example, the presence of a hole in the reflecting screen), its value is set using a checkbox.



*Some parameters may be interrelated. For example, in case of the Dove prism, changing the **Width** parameter will consequently result in the alteration of the **Right Height** and **Horizontal Shift** parameters.*

If you want to close the constructor, click any point on the screen outside of the constructor panel or scroll the mouse wheel. After closing the constructor, the changes made to the parameters of the object are saved. When placing an object on the optical bench, parameters are automatically applied to this object. When creating another object of the same type, previous changes in the constructor will be applied to it.

7.2 Numpad

The numpad (Figure 20) is designed to set an exact parameter value within the available range.



Figure 20 – Numpad

The input field (1) displays the current parameter value. Above is the step of parameter change (2). Buttons (3) and (4) are used to set the minimum or maximum parameter value within the available range.

The **Validate Value** button (5) located between the range boundaries has two functions:

- rounds the entered value with an acceptable accuracy for the indicator;
- sets the nearest value within the range in the field, if it goes beyond.

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

When the button  is pressed, the entered parameter value is saved and the numpad closes. If the entered parameter value is out of range or if all characters have been deleted, the button is blocked.

To close the numpad without saving the changes, press the button  or click outside the numpad.

8 Interacting with objects

8.1 Optical bench

The optical bench is an object in the scene on which or within which all other objects from the **Equipment** library can be placed or moved. The optical bench has a ruler for determining the distances between objects. The length of the optical bench is 50 cm.

All objects from the **Equipment** panel can only be created within the bounds of the optical bench, provided there is enough space for their placement and no conflicts with other equipment. Before an object is placed on the bench, a carriage (Figure 21) is displayed in the placement area. You can interact (move, delete) with both the object itself and the carriage in which it is located.

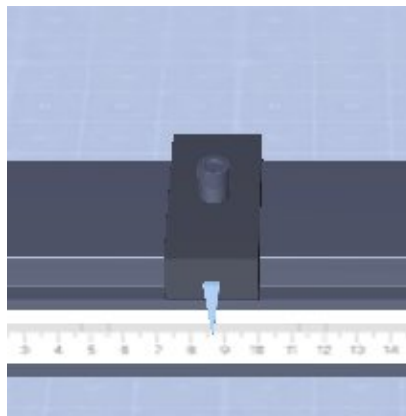


Figure 21 – Carriage for placing an object

8.2 Creating an object

To create an object on the optical bench:

- 1) Select the desired object's card from the **Equipment** panel (see [7 Equipment panel](#)). An info panel will appear on the screen and, if a constructor is provided for the object, the constructor panel will be opened (Figure 18). If necessary, set the parameters of the object to be created by specifying their values in the constructor (Figure 19).
- 2) Drag the object into the optical bench area. When the cursor moves from the card area towards the workspace, an object placement icon appears under the cursor. The appearance of the icon may depend on the possibility of placing the object (Table 1).

Table 1 – Types of placement icons

Icon Style	Description
	Can be created — an object icon and an arrow pointing towards where this object can be created or moved are displayed

Icon Style	Description
	Delete — is displayed if releasing the object will result in its removal. However, the object can be returned to its place by moving it in the direction of the arrow.
	Cannot create — is displayed if an object of this type cannot be placed on the bench because there exists an object (or objects) with which the new object is incompatible. Icons of objects that "interfere" with creating a new object are displayed in the upper right.
	Cannot create here — is displayed if the object cannot be placed at this point in the work area (for example, the object you are moving is far from the optical bench or you are trying to place the light source to the right of other objects on the bench). If you release the pointer <u>in this part of the workspace</u> , the object will not be created. However, the object can be created <u>by moving</u> it in the direction of the arrow.
	No space for creation — is displayed if there is no space on the optical bench to place the object (for example, there is not enough space from the left edge of the bench to the farthest left object already placed on the bench for a light source).

8.3 Deleting an object

To remove an object from the scene, click on the object or its carriage and drag it away from the optical bench. When a red outline and a trash can icon appear around the pictogram of the object (see the **Delete** pictogram in Table 1), release the pointer.

9 Object descriptions

9.1 Lights

Lights are different types of objects that emit light according to their inherent properties.



Only one light source can be created on the bench. The light source must be placed to the left of all other objects on the bench.

9.1.1 Directional light

A directional light is a device that forms and directs a parallel beam of light along the optical axis.

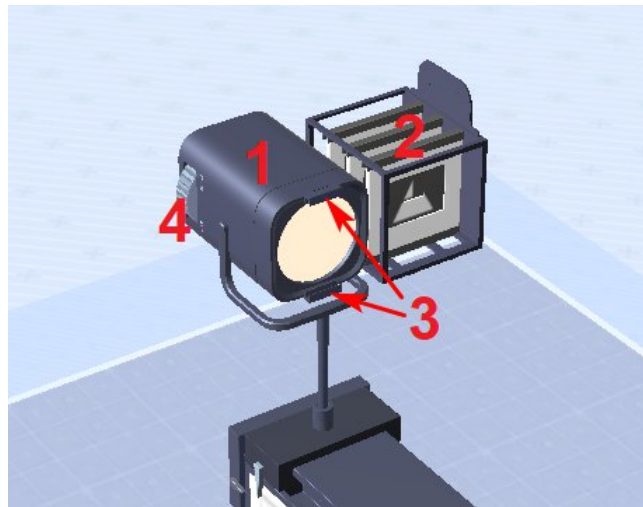


Figure 22 – Directional light

The directional light (Figure 22) consists of:

- 1) a projector (lantern) (1);
- 2) a container attached to the projector, with slides inside (2). The parallel beam of light acquires new properties as it passes through the slides;
- 3) slide fasteners from the container (3);
- 4) a brightness regulator (4). To change the brightness of the source, click on the regulator and, without releasing it, drag the pointer up or down.

Slides are arranged as follows: letter **F**, square, triangle. To set a slide in the projector's mounts, click on the container (2) and drag the pointer along the body of the light source (Figure 23). As the container is extended (if you don't release the pointer), the slides will be installed in the projector's mounts in turn: triangle, square, letter **F**. When the pointer is released, the last slide will remain on the projector.

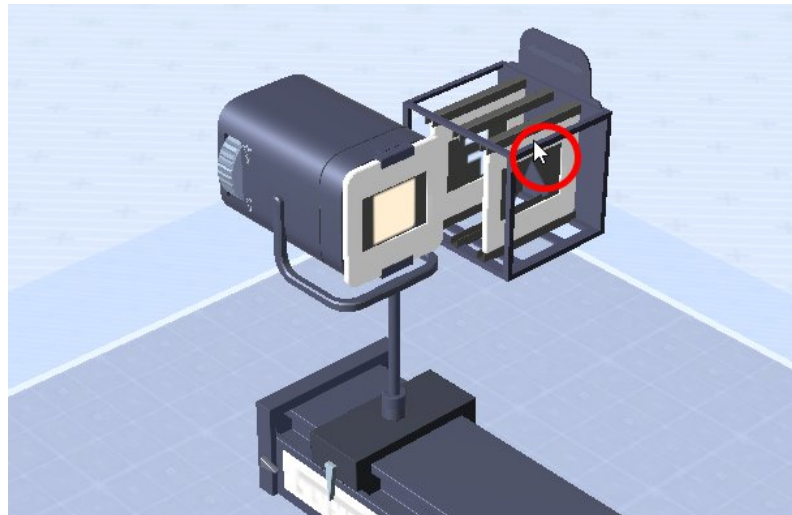


Figure 23 – Installing a slide in the projector's mounts

9.1.2 Scattered light

A scattered light is a device without a focused beam of light. Light rays diverge from the device in all directions. The source looks like an incandescent lamp and has a brightness regulator on the side (Figure 24). To change the brightness of the source, press the regulator and, without releasing it, drag the pointer up or down.

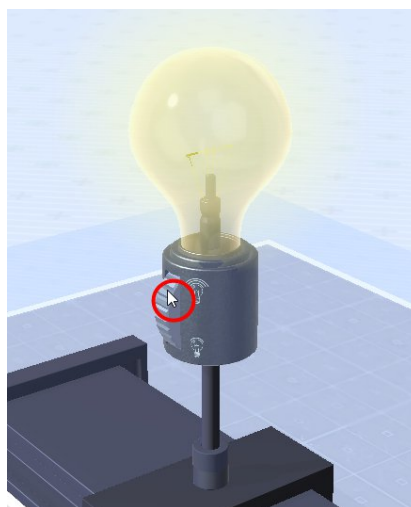


Figure 24 – Adjusting the brightness of the source



A scattered light cannot be located on the same optical bench with a Dove prism and a mirror.

9.1.3 Laser

A laser is a device that forms a coherent, monochromatic, polarized, and narrowly directed stream of light. The height of the source can be adjusted using the controller with arrows (Figure 25).

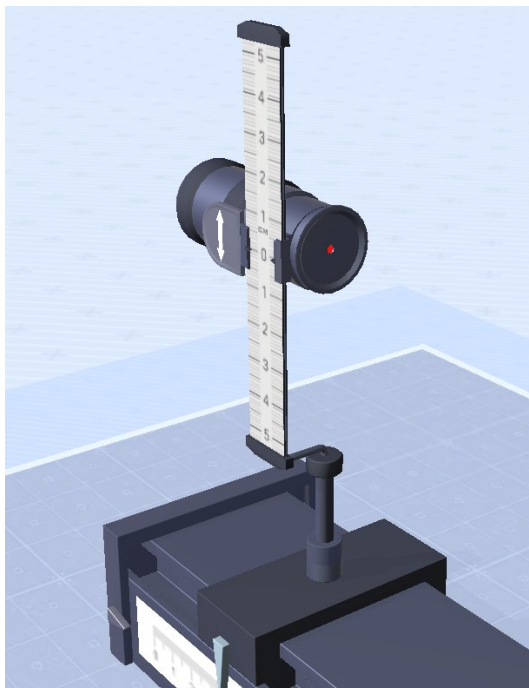


Figure 25 – Laser

The laser interacts with the Dove prism, diffraction grating, and screen, forming a device for measuring wavelength. The laser beam is split, passing through the diffraction slit.



A laser cannot be located on the same optical bench with a lens.

9.2 Lenses

Lenses are glass mediums that refract light rays passing through them. Any number of lenses can be created on the bench. They can only be placed between the light source and the reflector.

9.2.1 Convex Lens

A convex lens is a type of lens in which parallel rays passing through it converge at one point. In laboratory work, these lenses are used to calculate the focal length and the distance from the lens to the studied object.

The lens's focal length can be changed in the constructor (see [7.1 Object constructor](#)).

The image seen through the lens and in its reflection depends on all objects present in the scene.



A lens cannot be located on the same optical bench with a laser.

9.2.2 Dove prism

The system used in the Virtual Laboratory consists of an optical disk (1), a Dove prism mounted on it (2), and a tag for rotating the disk around its center (3) (Figure 26). The system is designed to calculate the refractive index of a laser beam.

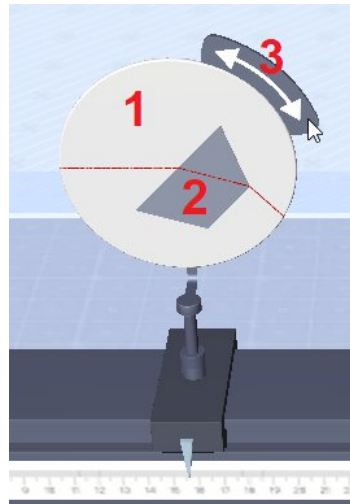


Figure 26 – Dove Prism

To rotate the disk with the prism, click on the tag and, without releasing, drag the pointer left or right.

The prism's material and parameters are set in the constructor (Figure 27).



Figure 27 – Dove Prism Constructor

The prism's material is selected from the list (1).

Linear parameters of the prism can be set in one of the following ways:

- Click and drag one of the corners of the schematic image of the prism (2).
- Click and drag one of the sides of the schematic image of the prism (3).
- Click and drag the central point of the schematic image of the prism (4). In this case, the prism will be shifted within the optical disc.
- Enter the exact value of the parameter by clicking the numpad button  (6).
- Set the value using the slider, by clicking in the slider area (7) or dragging the slider thumb (8).

The values set by one of the above methods will be displayed in the field of the current value (5).

If at least one Dove prism is created on the bench, a tablet with tools is displayed in the scene (Figure 28).

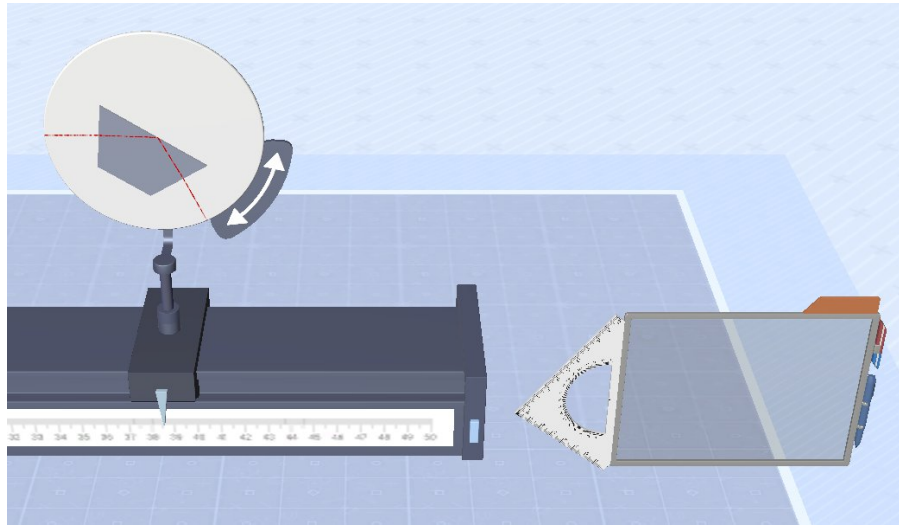


Figure 28 – Dove Prism and Tablet



A laser is the only possible light source compatible with the Dove prism.

9.2.3 Mirror

A mirror is a glass with a smooth surface intended for reflecting light. The mirror has a tab for rotating the mirror around its center (1) (Figure 29). If at least one mirror is created on the bench, a tablet (2) is displayed in the scene.

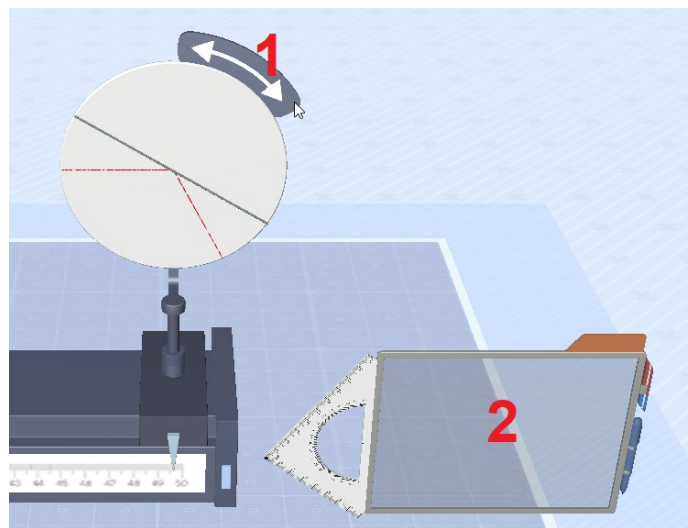


Figure 29 – Mirror and tablet



A laser is the only possible light source compatible with the Mirror.

The shape of the mirror is set in the constructor (see section [7.1 Object constructor](#)).

9.3 Spectral Instruments

Spectral instruments are objects that impart new properties to the light passing through them.

9.3.1 Two glass plates

Two glass plates is an object for conducting experiments on light interference in a liquid. It consists of two glass plates (positioned at a small angle to each other), a clamp, and a liquid between the plates.

The interference image depends on the force of the plate clamp and does not depend on other objects in the scene. Therefore, to change the light interference picture, you can loosen and tighten the clamp plates. To do this, click on the clamp handle (Figure 30) and pull it to the left or right.

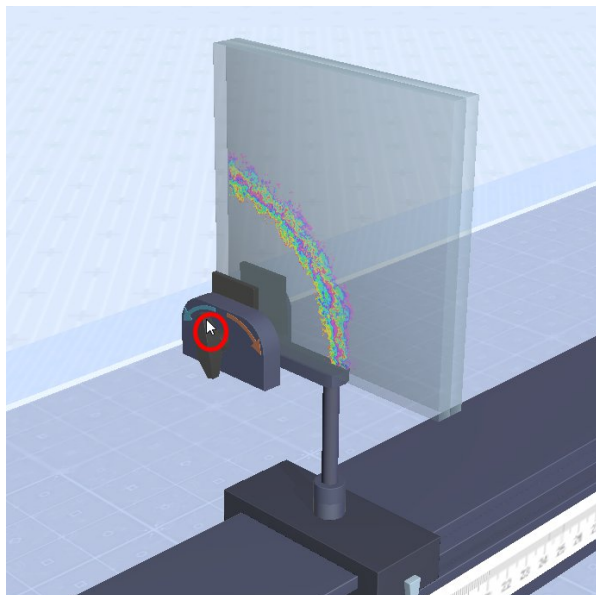


Figure 30 – Two glass plates

9.3.2 Diffraction slit

A screen with a diffraction slit is a plate that reflects light, with a small slit in the center for light to pass through. This screen is used to study light diffraction and light refraction in certain experiments, replacing devices for creating directed light.

Changes in the properties of light can be observed on the reflective screen placed to the right (Figure 31).

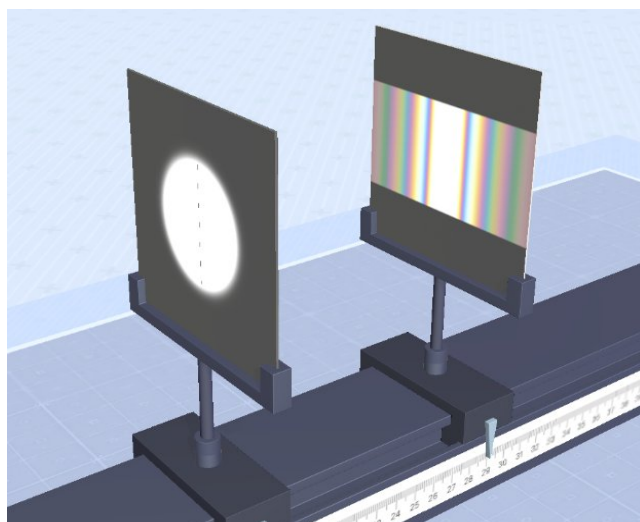


Figure 31 – Screen with a diffraction slit and a reflecting screen behind it

9.3.3 Diffraction grating

A diffraction grating is a grid with a large number of regularly arranged slits. The frequency of the slits is set in the object designer (see [7.1 Object constructor](#)). The diffraction grating allows you to observe the decomposition of light into spectral components on the reflective screen placed behind the grid (Figure 32).

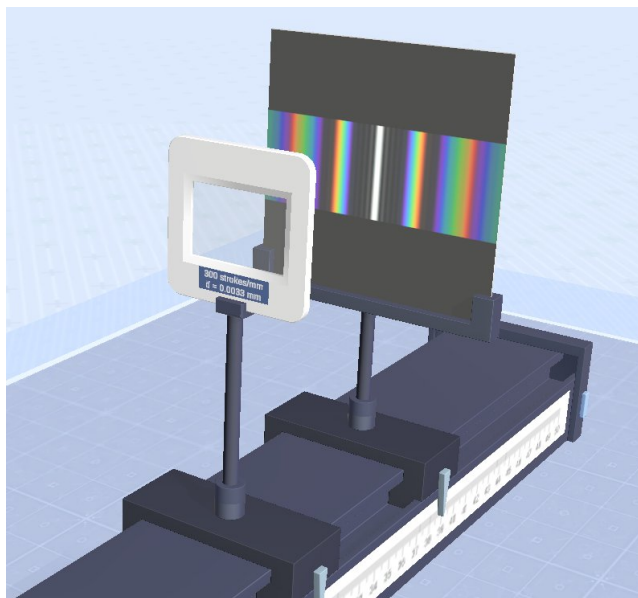


Figure 32 – Diffraction grating and a reflecting screen behind it

The laser beam divides the grating into different points, and you can use the wave length sensor to measure the length of the light wave (Figure 33).

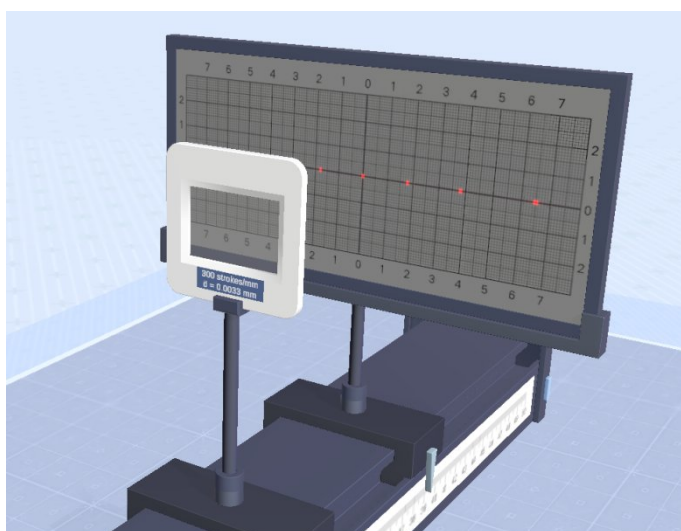


Figure 33 – Diffraction grating and a wave length sensor behind it

9.4 Reflectors

Reflectors are objects that reflect light. They are used to take an image of the light passing through other devices, such as lenses or a screen with a hole.



Reflector must be located to the right from all other objects on the bench.

9.4.1 Screen with a hole

A screen with a hole is a reflecting surface with a hole in the center for conducting experiments with shadows cast by this surface (Figure 34).

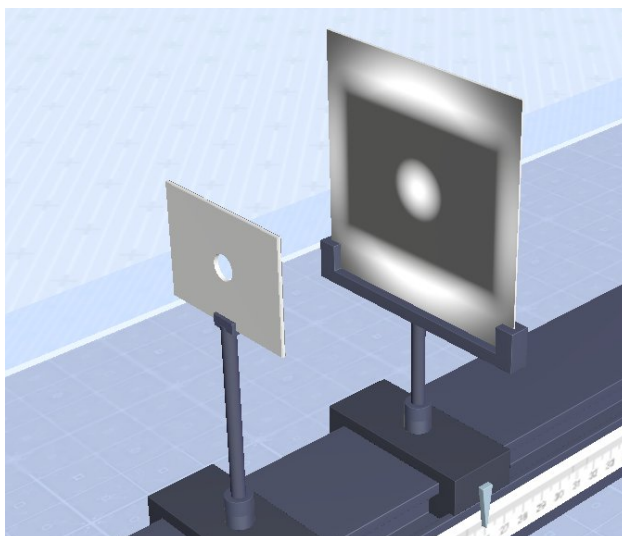


Figure 34 –Screen with a hole and a reflecting screen behind it

The shapes and sizes of the screen and the hole are set in the object designer (see [7.1 Object constructor](#)).

9.4.2 Screen

The screen is a reflecting surface that is set up to obtain a certain image. The screen reflects all the light that hits its surface. Beams emanating from the light source form an image on the screen according to the distortions obtained after passing through lenses or diffraction gratings, if they were installed. The properties of the image are used to determine the properties of various devices on the optical bench. Figure 35 shows a screen with an image obtained after scattered light has passed through a convex lens.

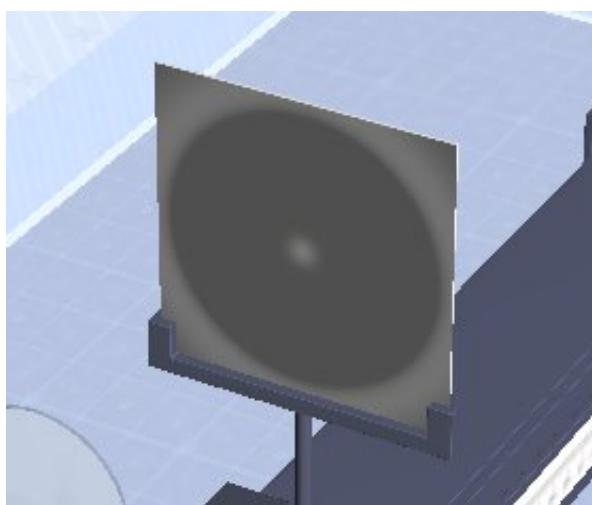


Figure 35 – Screen

9.4.3 Wave length sensor

The wave length sensor is a reflecting surface with millimeter ticks (Figure 36). The device is designed to determine the wavelength of light based on the observed properties of light diffraction. The screen reflects all the light that hits its surface.

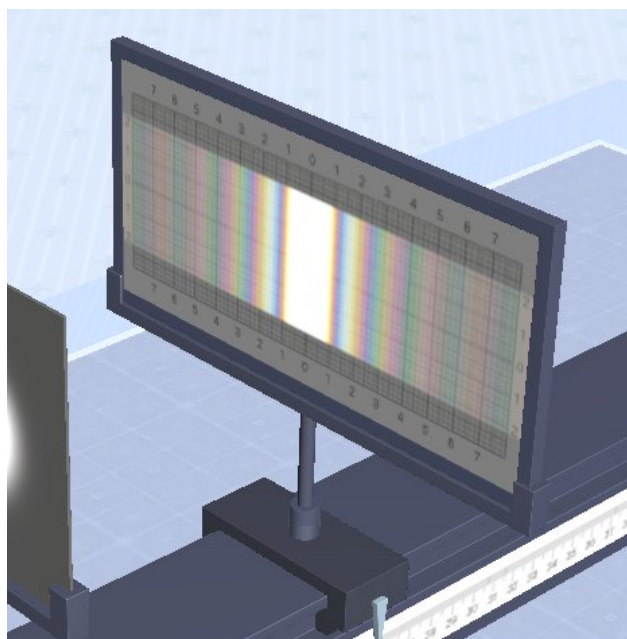


Figure 36 – Wave length sensor

9.5 Drawing tablet

The drawing tablet is a set of objects for visually recording the results of laboratory work and performing calculations (Figure 37). The set consists of a transparent tablet (1), marker (2), eraser (3), and an angle ruler (4).

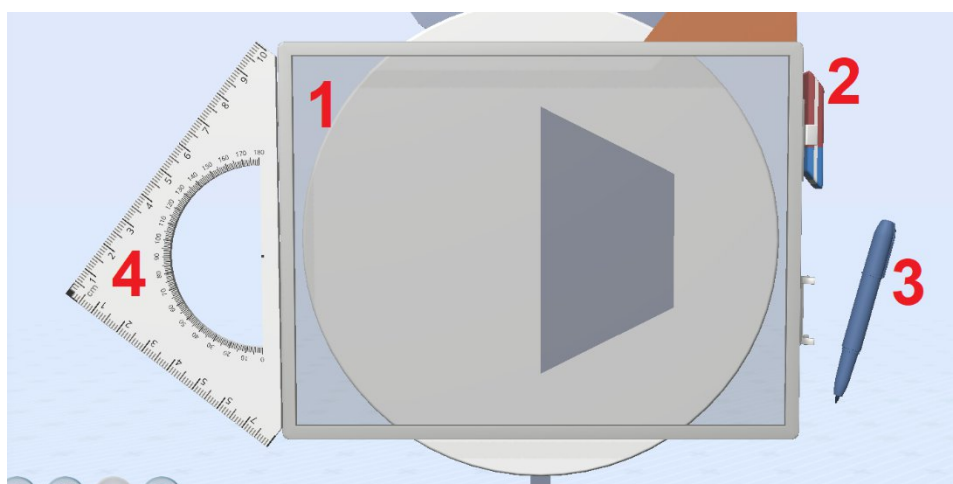


Figure 37 – Drawing tablet

The tablet appears in the scene when a Dove prism (Figure 38) or mirror is placed on the optical bench and is removed from the scene when these objects are removed.

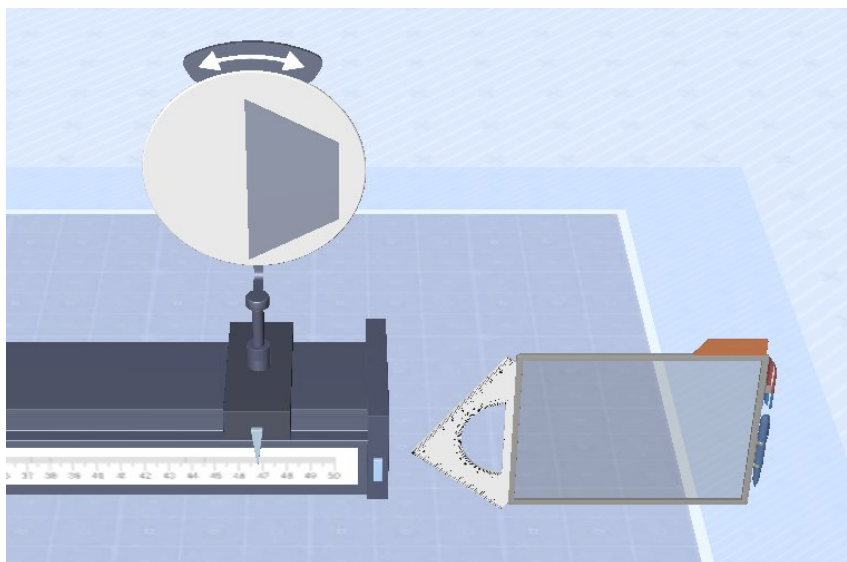


Figure 38 – Dove Prism and Tablet

The tablet can be attached to the optical disc of the prism or to the mirror. To do this, click on the tablet and drag it to the prism or mirror. If there are several objects on the bench to which the tablet can be attached, transparent copies of the tablet will be displayed on all of them in the positions where you can attach it (Figure 39).

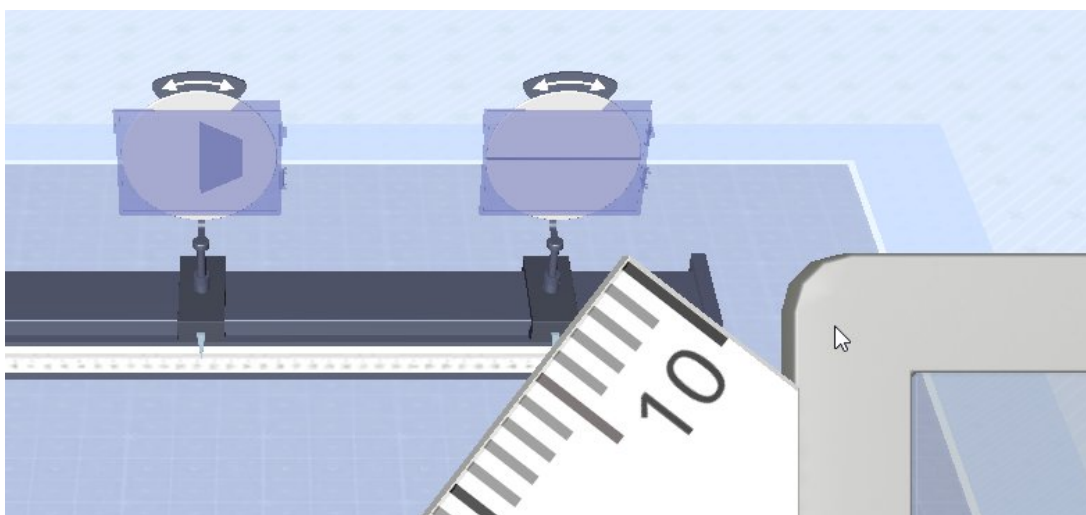


Figure 39 – The tablet can be attached to the prism or the mirror

To remove the tablet from the object, click on the tag as shown in Figure 40 and pull it towards the free space in the scene. The tablet will be placed to the right of the optical bench. In a similar way, you can move the tablet to attach it to another object (prism or mirror).

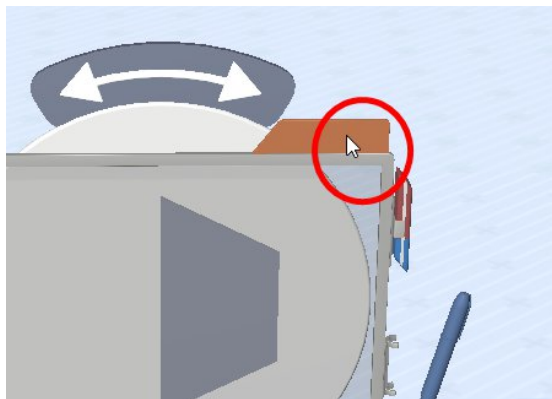


Figure 40 – Removing the tablet from the object

You can draw straight lines along the ruler with the marker on the transparent surface, as well as erase these lines with the eraser.

If you have drawn lines on the tablet and removed the tablet from the object, the drawn lines on the tablet will remain. This can be useful, for example, if you want to compare the refraction of a beam in a Dove prism made of different materials (Figure 41).

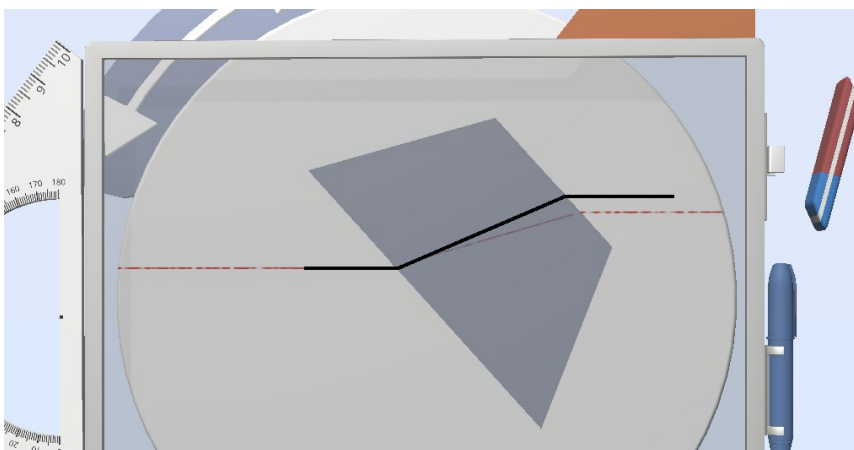


Figure 41 – Comparing the refraction of a beam in a prism made of glass and diamond

9.5.1 The ruler

The ruler takes the form of a triangle with a protractor and is by default located in its slot on the left side of the tablet (Figure 42).

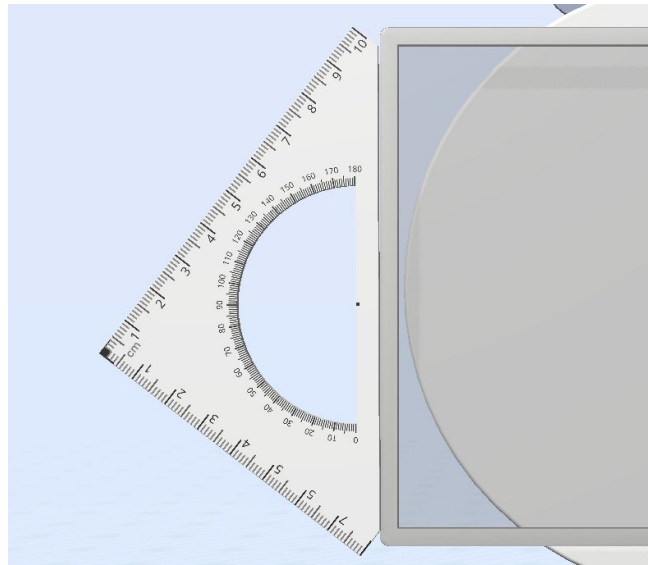


Figure 42 – Ruler

You can set the ruler at any angle on the surface of the tablet to draw lines and make measurements.

To do this:

- hold down the ruler with the left mouse button or finger when using a touch screen and move the ruler along the surface of the tablet. To position the ruler more precisely, hold down the Ctrl key while moving it.
- hover over the ruler with the cursor and rotate the mouse wheel. The ruler will rotate around the pointer. To rotate the ruler faster, hold down the Shift key while rotating it.

When using a touch screen, hold one point on the ruler with one finger (this is the center of rotation), and rotate the second finger around the first, setting the angle of rotation.

You can rotate and move the ruler along the tablet at the same time.

You can use the ruler to draw straight lines along the outer sides of the ruler with a marker on the tablet. The inner semicircle for drawing is not available.

To prevent the ruler from obstructing the view of the drawn lines, move it out of the tablet. The ruler will return its designated slot.

9.5.2 Marker

The marker is a tool for drawing straight lines along the ruler. If the tablet is attached to an object, then the marker is active and displayed to the right of the tablet (Figure 43). The inactive marker is located in its slot on the right side of the tablet (Figure 44), if:

- the tablet is on the desktop and is not attached to an object;
- the tablet is attached to an object, but the eraser is active.

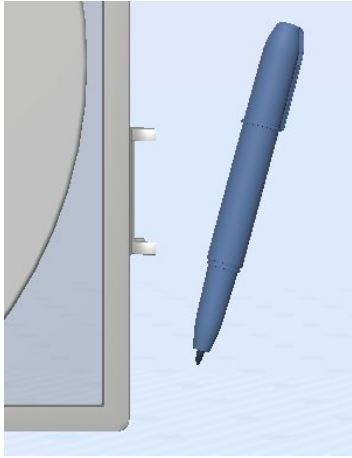


Figure 43 – Active marker

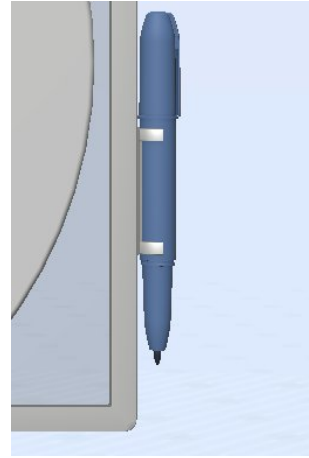


Figure 44 – Inactive marker

To draw a line on the tablet:

- 1) If the marker is inactive, activate it by clicking on it.
- 2) Place the ruler at the desired location on the tablet at the desired angle.
- 3) Move the pointer to the point on the tablet at the edge of the ruler where the line should begin.
- 4) Hold down the pointer and drag it along the edge of the ruler. As soon as you start moving the pointer, an image of the line will appear. The marker will "pass through" points that are the projections of the pointer onto the edge of the ruler (Figure 45).

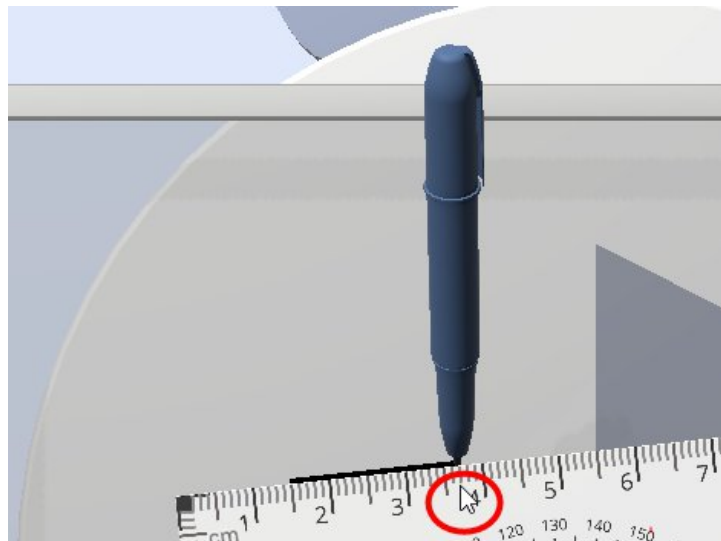


Figure 45 – Drawing a line

9.5.3 Eraser

The eraser is a tool for erasing lines on the tablet. The eraser is inactive when the tablet is located on the workbench and not attached to any specific object. When the marker is active, the eraser is also inactive and is located in its slot on the right hand side of the tablet (Figure 46). Clicking on the eraser activates it (Figure 47) and deactivates the marker.

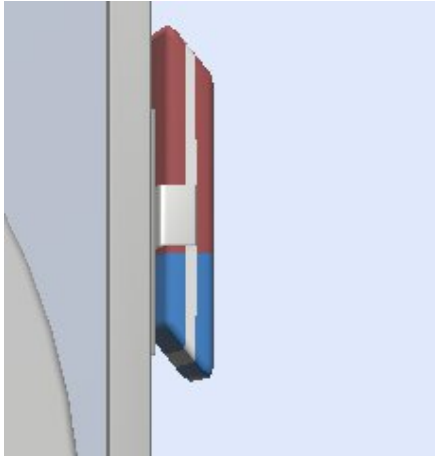


Figure 46 – Inactive eraser

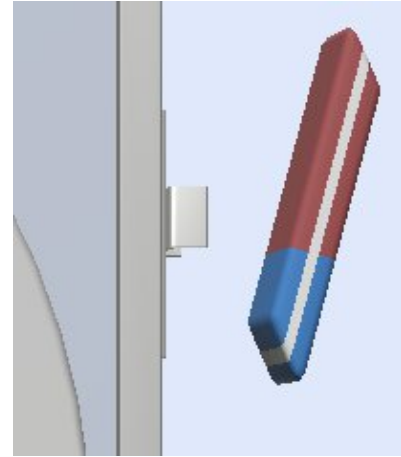


Figure 47 – Active eraser

To erase a line on the tablet:

- 1) If the eraser is inactive, activate it by clicking on it.
- 2) Move the pointer to the line you want to erase.
- 3) Hold down the pointer and drag it along the line you want to erase. As soon as you start moving the pointer, an image of the eraser will appear under it, and the image of the line under the pointer will disappear. The eraser will "erase" the points that are the projection of the pointer on the line being erased (Figure 48).

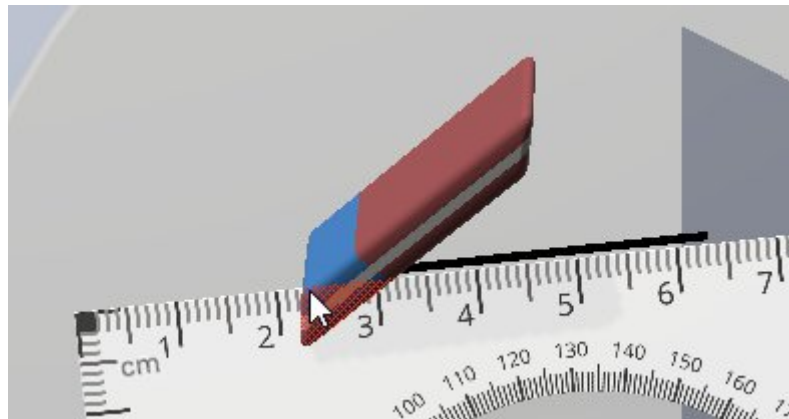


Figure 48 – Erasing a line