



Virtual laboratory



TECHNOLOGY

3D modeling. Sylaedr

User
manual



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Terms and Definitions

Term	Definition
Virtual Laboratory	Virtual Laboratory "Technology", section "3D modeling. Sylaedr"
GIZMO	Gizmos are manipulators used to control rotation, movement, and scaling for a selected object
Camera	A scene tool with which the user observes everything that happens in the Virtual Laboratory
Click	Pressing and releasing the pointer without moving
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
Shell	A hollow shape with a wall thickness small compared to its other dimensions
Operand	One of the figures that are used to perform a Boolean operation, that is, the operation of union, intersection or subtraction of several figures. As a result of a Boolean operation, one final figure is obtained
Pivot	The geometric center of one figure or a point whose coordinates are determined as the average values of the corresponding coordinates of the geometric centers of several figures
Workspace	Part of the scene within which the user can interact with the objects of the Virtual Laboratory available to him. In the application workspace, the user can open either a perspective view of the scene or one of the orthogonal views: frontal, horizontal or profile
Stiffening rib	The part of a detail or structure that bears the main load. Due to this, the product becomes less susceptible to deformation and can withstand greater weight and force
Slider	An interface element that allows the user to select a value from a specified range (continuous or discrete). Moving the slider bar allows you to increase/decrease the selected value
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.)
Pointer	A user interface element, a graphical symbol that is moved across the screen under the control of an input device (for example, an arrow that is moved across the screen using a mouse). Examples of input devices: mouse, pen, stylus, touchpad or just a finger in case of a touchscreen. Using a pointer, the user selects an object or interacts with it. In this manual, the following terms will be used to describe actions with pointers: • click on the pointer — move the pointer and click (with the left mouse button, finger, etc.); • click with the pointer — move the pointer, press and release; • move the pointer — press, move and release

1 System requirements

Minimum system requirements for the Virtual Laboratory "Technology", section "3D modeling. Sylaedr" are:

- **Processor:** Intel Ivy Bridge series / AMD Bulldozer series;
- **RAM:** 4 GB;
- **Graphics Card:**
 - Integrated: Intel HD Graphics 5000 / Intel Iris;
 - Discrete: GeForce 400 series or newer / Radeon HD 7000 series;
- **Screen Resolution:** 1920x1080 / 1920x1200 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

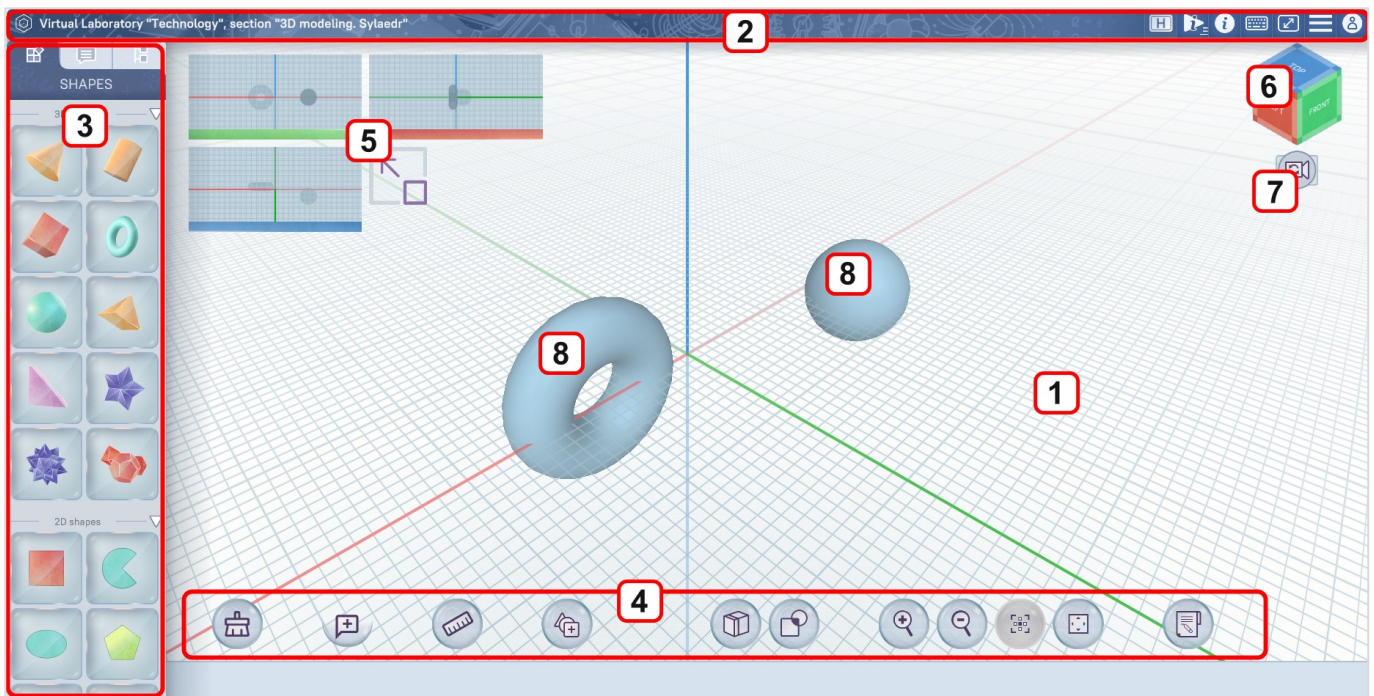


Figure 1 –The Interface of the Virtual Laboratory

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

- 1) **scene** (see [2.1 Scene](#));
- 2) **Application Header panel** (see [2.2 Application Header panel](#));
- 3) **left panel** (see [2.3 Left panel](#)). It contains three tabs: **Shapes**, **Comments** and **List of Objects**;
- 4) **control panel** (see [2.4 Control panel](#)). When you switch to one of the orthogonal views, the **Spline** button  additionally appears on the panel. When the **Kinematic Operations** (see [3.7 Kinematic Operations](#)) or **Boolean Operations** (see [3.8 Boolean Operations](#)) are selected, the **Select Kinematic Operation panel** is displayed. For the kinematic operation **Moving Along a Trajectory**, **Trajectory and sketch selection panel** is additionally displayed;
- 5) **orthogonal views panel** (see [2.5 Orthogonal views panel](#));
- 6) **Camera Rotation Cube** (or the **Cube manipulator**) is used to control the rotation of the camera (see [4.2 Cube manipulator](#));
- 7) **Default Camera button**  (see [4.4 Default Camera button](#));
- 8) **objects** in the scene.

In addition, when there is at least one selected object in the scene, the following interface elements are displayed in the work area (Figure 2):

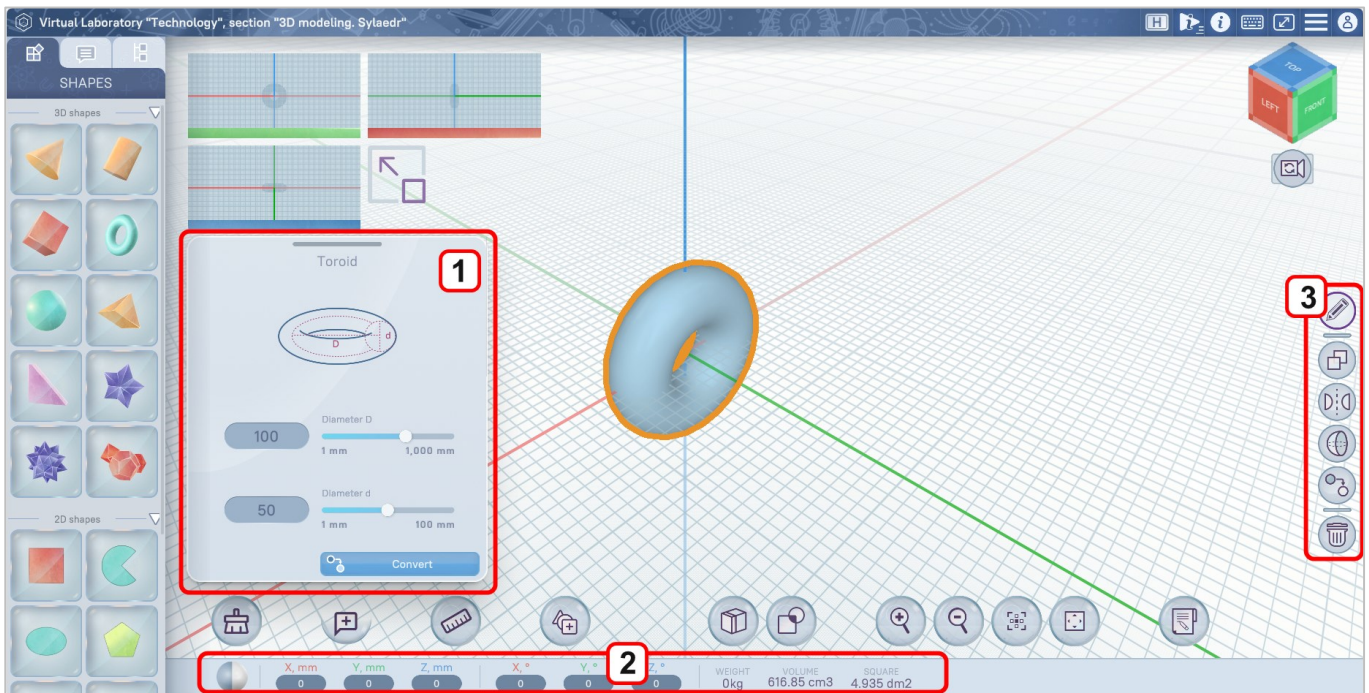


Figure 2 – Interface elements displayed when an object is selected

- 1) **shape settings panel** — displayed when a parametric 2D or 3D shape in editing mode is selected (see [2.6 Shape settings panel](#));
- 2) **properties panel** (material, coordinates and quantitative characteristics of the shape) (see [2.7 Properties panel](#));
- 3) **context menu** (see [2.8 Context menu](#)).

Under certain conditions, manipulators in the form of arrows, balls, and cubes are displayed in the scene — these are GIZMO manipulators (Figure 3). They serve to move, rotate, and scale the selected object (see [2.9 GIZMO manipulators](#)).

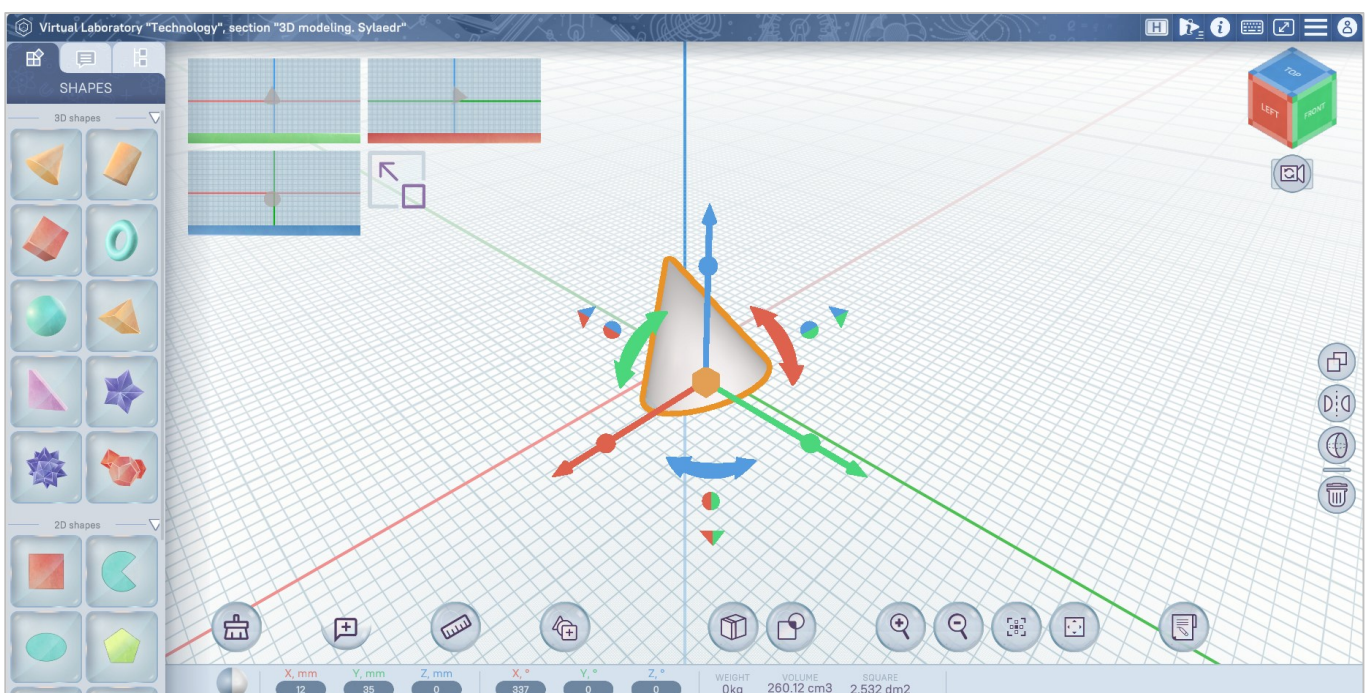


Figure 3 – GIZMO Manipulators

2.1 Scene

Four types of scene display are available in the Virtual Laboratory: perspective (Figure 4) (selected by default) and three orthogonal, each of which corresponds to one of the projections — horizontal, frontal and profile (Figure 5 – Figure 7).

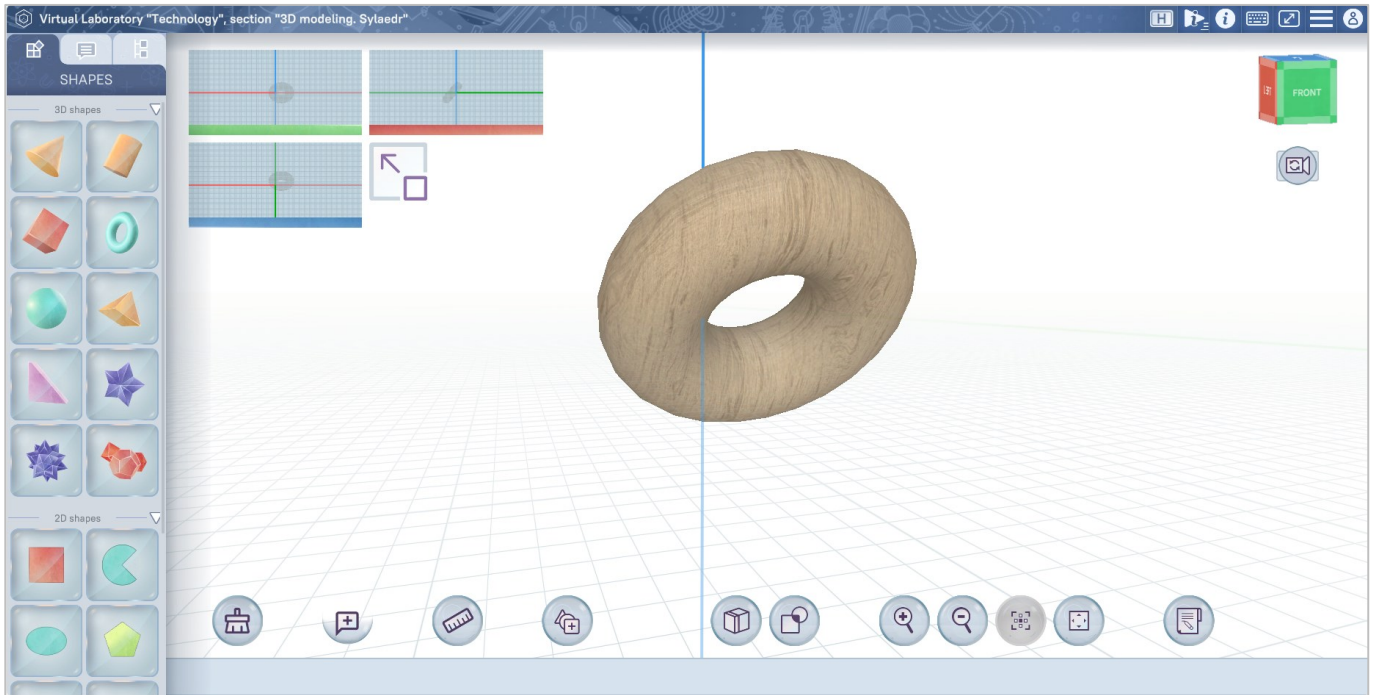


Figure 4 – Perspective view

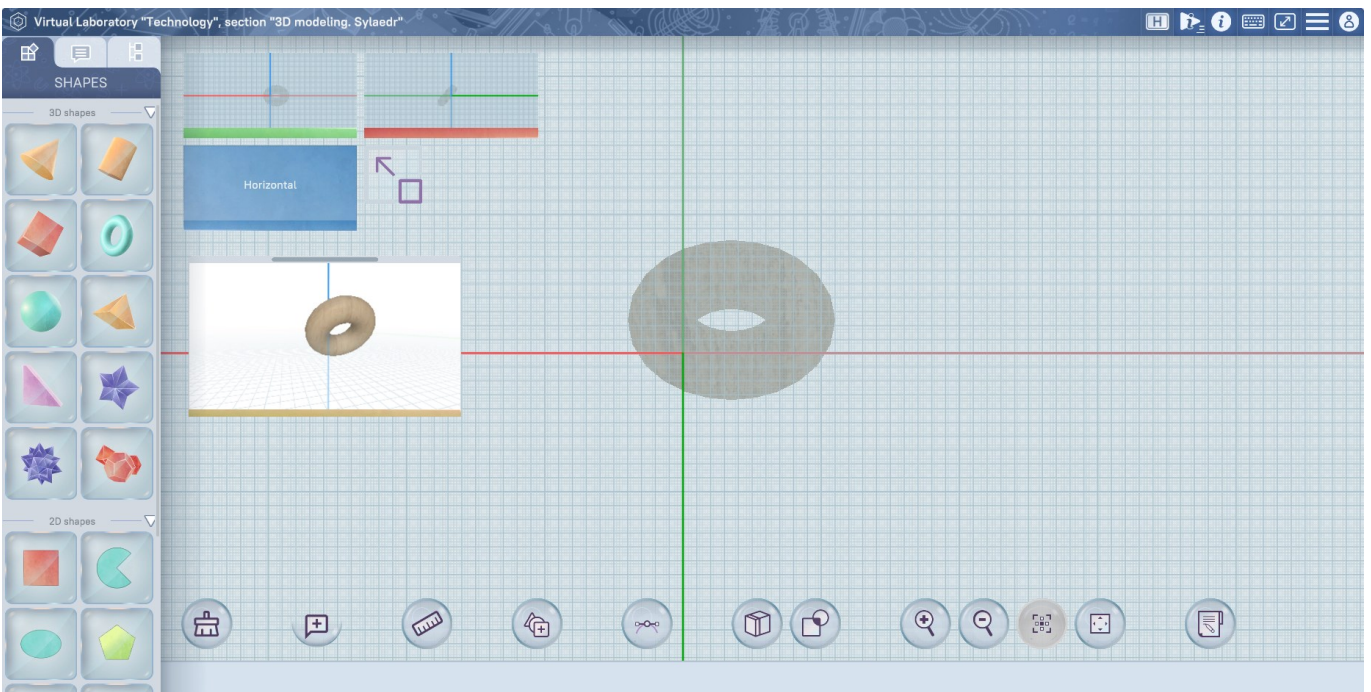


Figure 5 – Horizontal view

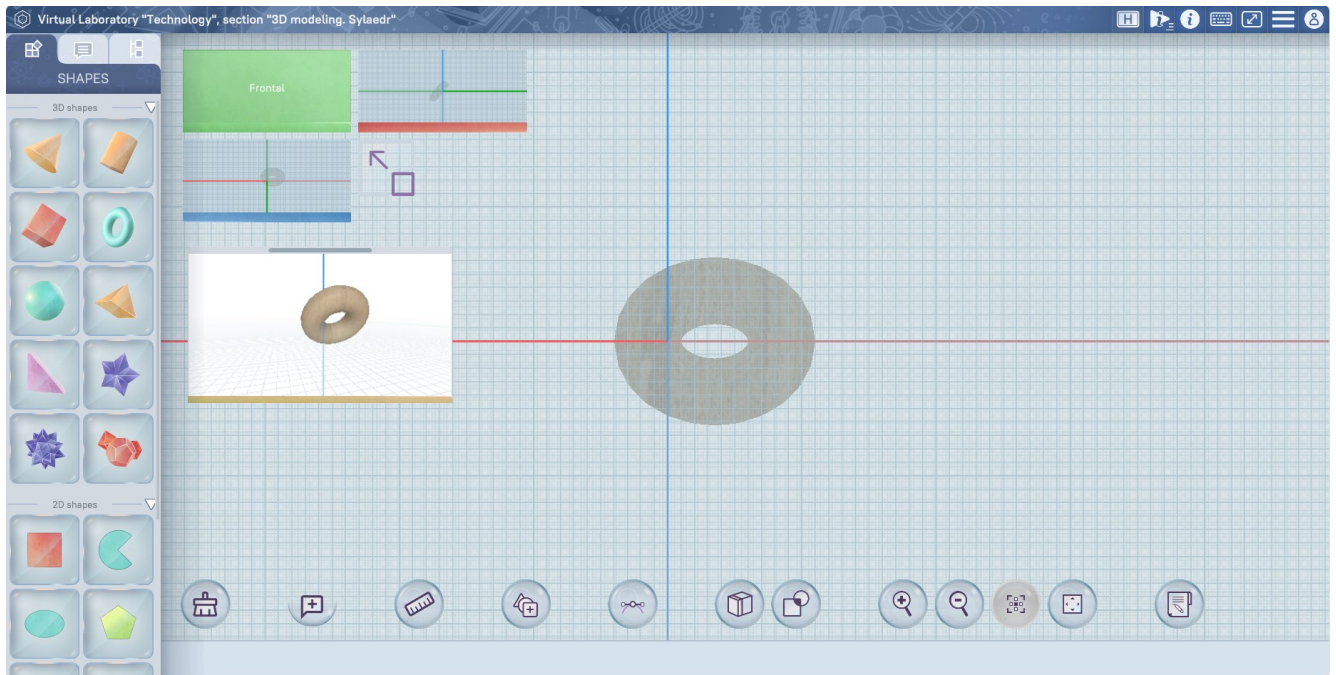


Figure 6 – Frontal view

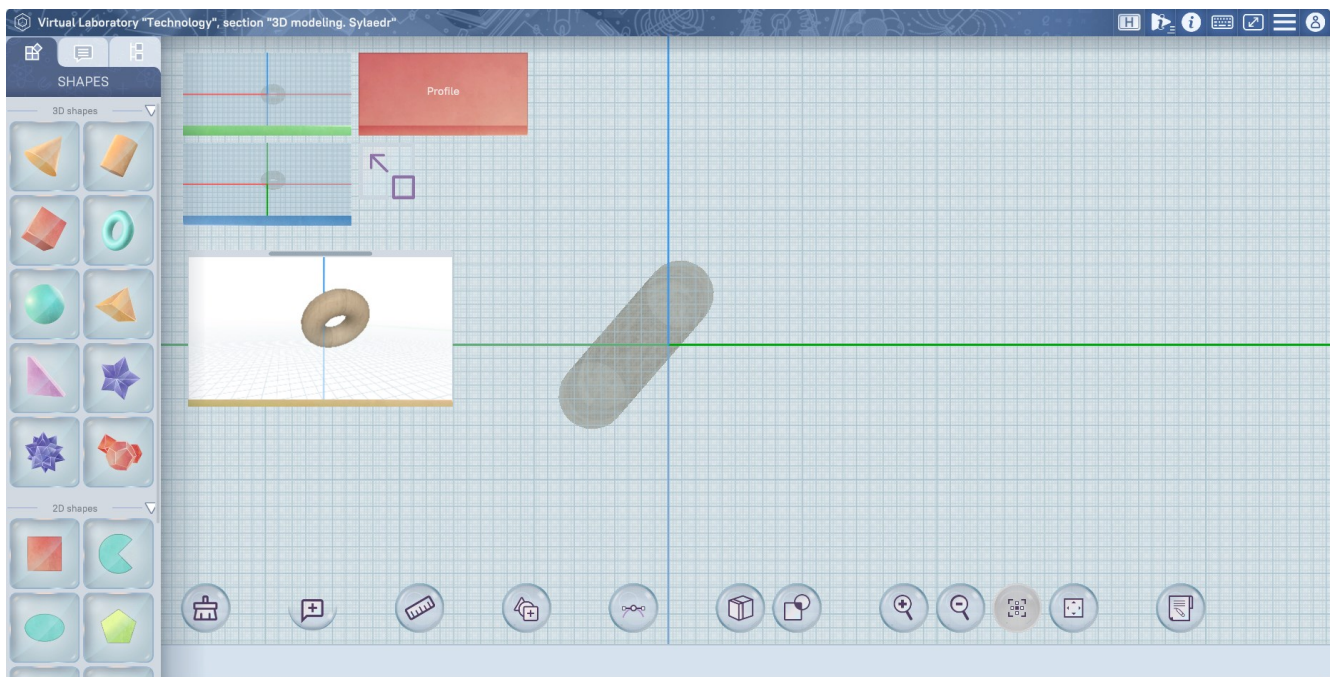


Figure 7 – Profile view

In **perspective view**, three positively directed coordinate axes are displayed from the point specified as the origin (zero) of coordinates: X axis is red, Y axis is green and Z axis is blue (Figure 8). The scale-coordinate grid is located in the XY plane.

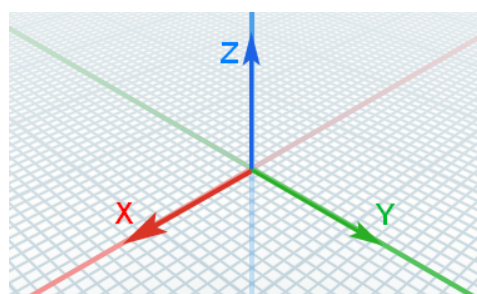


Figure 8 – Coordinate axes colors

In **orthogonal views**, two coordinate axes and a scale-coordinate grid are displayed, located in the plane corresponding to the active view (Figure 5 – Figure 7).

Switching between perspective and orthogonal views is done using the elements of the orthogonal views panel and the minimized perspective view window (see [2.5 Orthogonal views panel](#)).

2.2 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 9):



Figure 9 – Functional buttons of the Application Header panel

- button to open/close a list of hotkeys  (see [2.2.1 Hotkeys](#));
- button to open the Virtual Laboratory instructions  (see [2.2.2 Instructions](#));
- button to turn on/off the Tips mode  (see [2.2.3 Tips mode](#));
- button to turn on/off the Virtual Keyboard mode  (see [2.2.4 Virtual Keyboard](#));
- button to turn on/off the Fullscreen mode  (see [2.2.5 Fullscreen mode](#));
- button to open the scene-work menu  (see [2.2.6 Scene-work menu](#));
- user menu button  (see [2.2.7 User profile](#)).

2.2.1 Hotkeys

To open the list of hotkeys (Figure 10) press the **Hotkeys** toggle-button  on the **Application Header** panel:

A hotkey press can be processed longer when:

- the input field is inactive (the cursor is not placed in the field);
- the mouse button is not pressed;
- the finger does not touch the screen.



Figure 10 – Hotkeys list

If the input field is active (in the shape settings panel, in the scene card, etc.), then when you press the keyboard keys, the functions listed in the list of hotkeys do not work, but characters are entered into the input field.

To view the entire list of hotkeys, use the scroll bar at the right edge of the list box.

To close the list, click the  button in the **Application Header** panel.

2.2.2 Instructions

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 11).

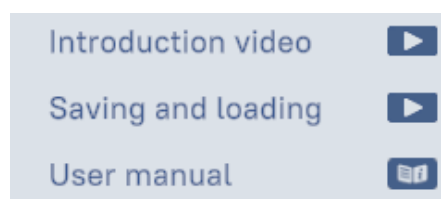


Figure 11 – Instruction selection menu

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 12).

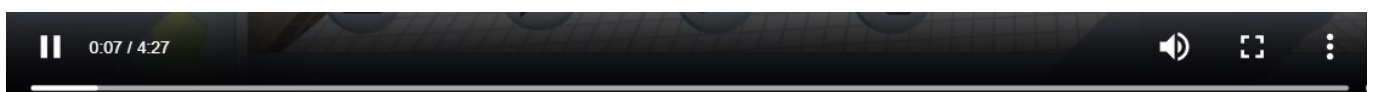


Figure 12 – Player control elements

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.

2.2.3 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 13).

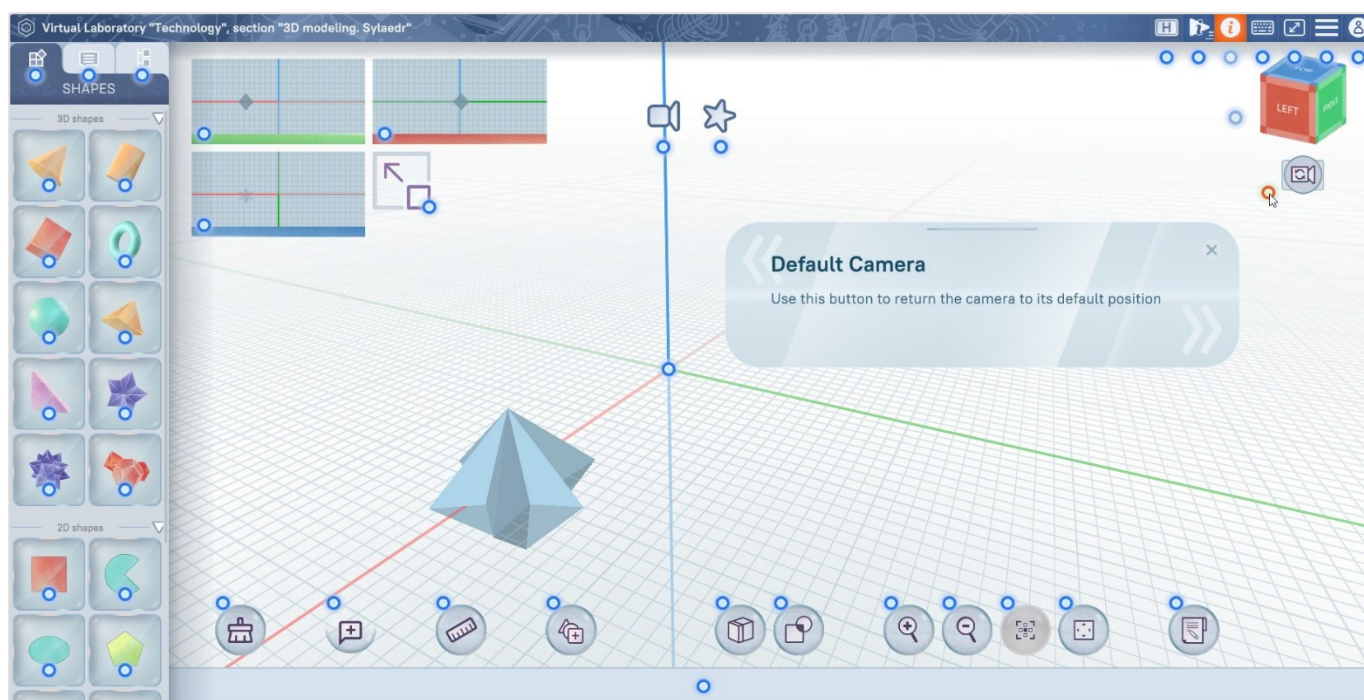


Figure 13 – Tips mode

To close the tip panel, press the tip-point again or click on the cross in the upper right corner of the panel. 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:

- dot with orange outline  — the prompt is open on the screen (Figure 13);
- dot with gray outline  — the user previously viewed and closed the tooltip;
- dot with blue outline  — the user has not yet viewed this tip.

In addition, the Virtual Laboratory has two hidden icons with tips: **Camera Control** and **Object Editing** (Figure 14). They are visible only in Tips mode.



Figure 14 – Hidden tips icons

To exit Tips mode, click the Tips button  in the **Application Header** panel.

2.2.4 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 15).



Figure 15 – Virtual Keyboard

The Virtual Keyboard has three layouts: Latin 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.

2.2.5 Fullscreen mode

To enable Fullscreen 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.

2.2.6 Scene-work menu

While working in the Virtual Laboratory, you can:

- save the current scene (see [2.2.6.1 Saving the scene](#));
- save a copy of the current scene (see [2.2.6.2 Saving a scene copy](#));
- create a new scene (see [2.2.6.3 Creating a new scene](#));
- open the **My scenes** library (see [2.2.6.4 Viewing and loading user scenes](#));
- share a link to the current scene (see [2.2.6.5 Saving a link to a scene](#)).

All these actions can be performed using the scene-work menu. The menu opens when you press the button  on the **Application Header** panel (Figure 16).

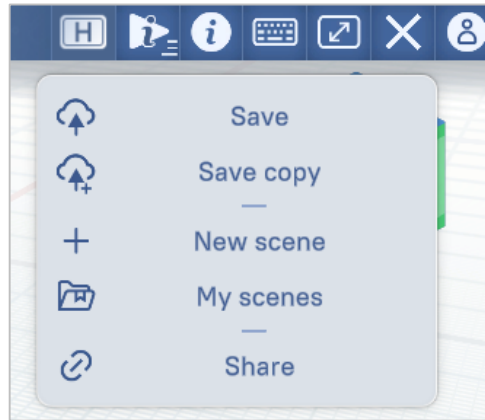


Figure 16 – Scene-work menu

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

2.2.6.1 Saving the scene

To save a scene to the **My scenes** library, select **Save** in the scene-work menu (Figure 16).

If the scene has already been saved, the application will overwrite the contents of the scene file. If the scene is being saved for the first time, the **Save scene** form will open (Figure 17).

Figure 17 – 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 [2.4.5 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 [2.2.4 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 .

2.2.6.2 Saving a scene copy

To save a copy of the scene in the **My scenes** library, select **Save copy** in menu (Figure 16). This will open the form for saving a copy of the scene, which is similar to the scene saving form (Figure 17).

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

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

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 2.4.5 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 .

2.2.6.3 Creating a new scene

To create a new scene, select **New scene** in the drop menu (Figure 16). If there are unsaved data, a window with a warning about possible data loss will open (Figure 18).

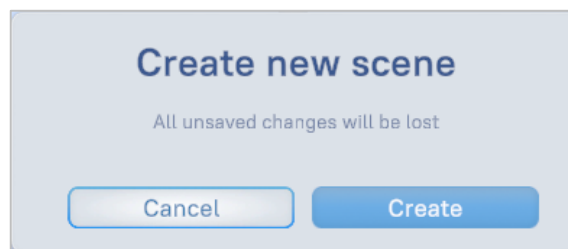


Figure 18 –Create New Scene window

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.

2.2.6.4 Viewing and loading user scenes

To view a list of scenes, select **My scenes** in the menu (Figure 16). The **My scenes** library page will open (Figure 19).

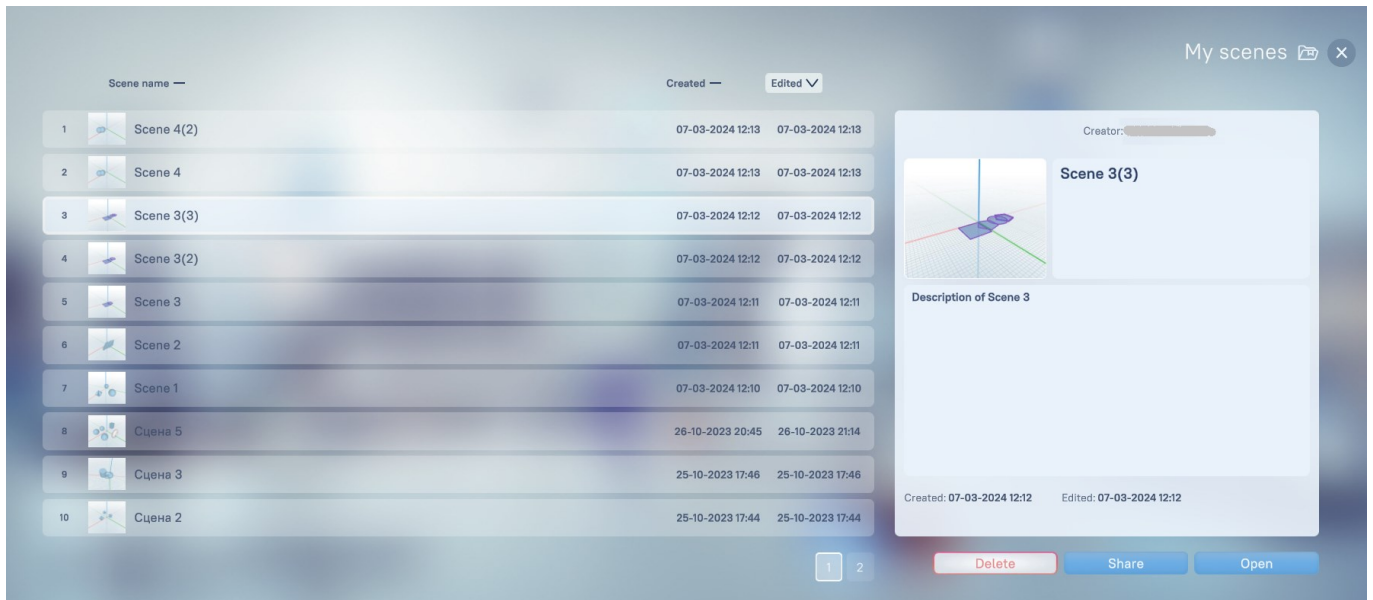


Figure 19 – My scenes library

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.

2.2.6.5 Saving a link to a scene

To share a link to the current scene, select **Share** in the menu (Figure 16). 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 17) will appear. You can save the link from the clipboard or send it to someone.

2.2.7 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 20).

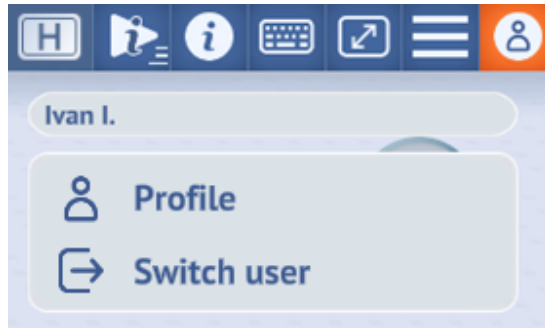


Figure 20 – User menu

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

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

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

2.3 Left panel

To the left of the work area is a panel that consists of three switchable tabs (Figure 21):

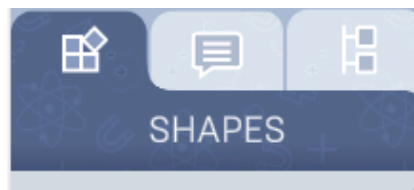


Figure 21 –Three left panel tabs

- the **Shapes** tab  is selected by default and contains a library of those shapes that can be created in the scene (see [2.3.1 Shapes tab](#));
- the **Comments** tab  contains a list of your comments on the currently open scene (see [2.3.2 Comments tab](#));
- the **List of Object** tab  contains all objects that you have placed in the currently open scene (see [2.3.3 List of Objects tab](#)).

Each tab has a scroll bar on the right.

2.3.1 Shapes tab

The **Shapes** tab contains the Virtual Lab's library of shapes. The library consists of subsections **3D shapes** (Figure 22) and **2D shapes** (Figure 23) with cards for creating shapes in the scene.



Figure 22 – 3D shapes



Figure 23 – 2D shapes

If using one card you can create several different shapes, then one of them is depicted, for example, as a sphere on the card for creating a sphere, or several shapes at once, as on the card of a regular polyhedron. To the right of the section name is a button, by clicking on which you can collapse/expand the section.

The following **3D shapes** are available in the library:

- **cone**. By changing the parameters of this figure, you can get a straight, truncated or inclined cone;
- **cylinder**. By changing the parameters of this figure, you can get a straight or inclined cylinder;
- **prism**. By changing the parameters of this figure, you can get the following figures: cube, parallelepiped, triangular, hexagonal prism, etc.;
- **torus**. By changing the parameters of this figure, you can get a closed or open torus;
- **ellipsoid**. By changing the parameters of this figure, you can get a sphere or an ellipsoid;
- **pyramid**. By changing the parameters of this figure, you can get a straight, truncated or inclined pyramid with a different number of faces: triangular, quadrangular pyramid, etc.;
- **support**. By changing the parameters of this figure, you can get stiffeners of several common shapes: a triangle shape, a rectangular trapezoid, a rectangle or a rectangle with a cut corner. To obtain a stiffener of any shape, use a spline (see [3.6 Spline](#)) and the extrusion operation (see [3.7.3 Extrusion](#));
- **volumetric star**. By changing the parameters of this figure, you can get three-dimensional stars with a different number of vertices;
- **star polyhedron**. By changing the type of this figure, you can get a small stellated dodecahedron, a large stellated dodecahedron, a large dodecahedron, and a large icosahedron. By changing the

Transformation option, you can create polyhedra of new shapes. To return to the original shape, set the Transformation value to zero;

- **regular polyhedron.** By changing the type of this figure, you can get the following figures: dodecahedron, icosahedron, octahedron.

The following **2D shapes** are available in the library:

- **rectangle.** By changing the parameters of this figure, you can get a square or rectangle;
 - **circle/sector.** By changing the angle, you can get a circle or sector of a circle;
 - **ellipse.** By changing the diameters of this figure, you can get an ellipse or a circle;
 - **polygon.** By changing the parameters of this figure, you can get regular (equilateral) polygons: triangle, pentagon, hexagon, etc.;
 - **trapezoid.** By changing the parameters of this figure, you can get a parallelogram or various forms of trapezoids;
 - **right triangle.** By changing the parameters of this figure, you can get a right triangle of given dimensions. To obtain a stiffening rib from it, use the extrusion operation (see [3.7.3 Extrusion](#));
 - **rhombus.** By changing the parameters of this figure, you can get a rhombus with the given dimensions of its diagonals;
- function graph. Using this object, you can create a graph of a function of your choice (see [3.5 Function graph](#)). After determining all the parameters, you can convert the desired part of the graph into a spline.

2.3.2 Comments tab

Click the **Comments** tab icon to open a list of all the comments you have created for the current scene (Figure 24).

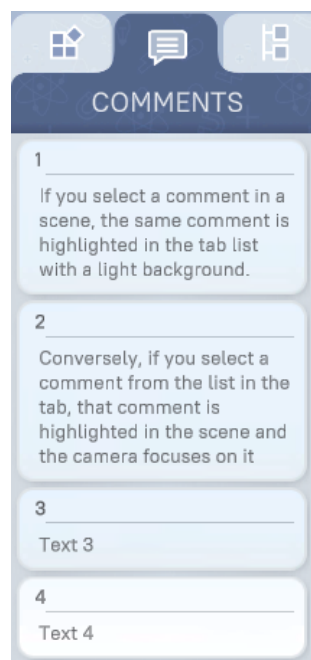


Figure 24 – Comments tab

If you select a comment in a scene, the same comment is highlighted in the tab list with a light background. Conversely, if you select a comment from the list in the tab, that comment is highlighted in the scene and the camera focuses on it (Figure 25).

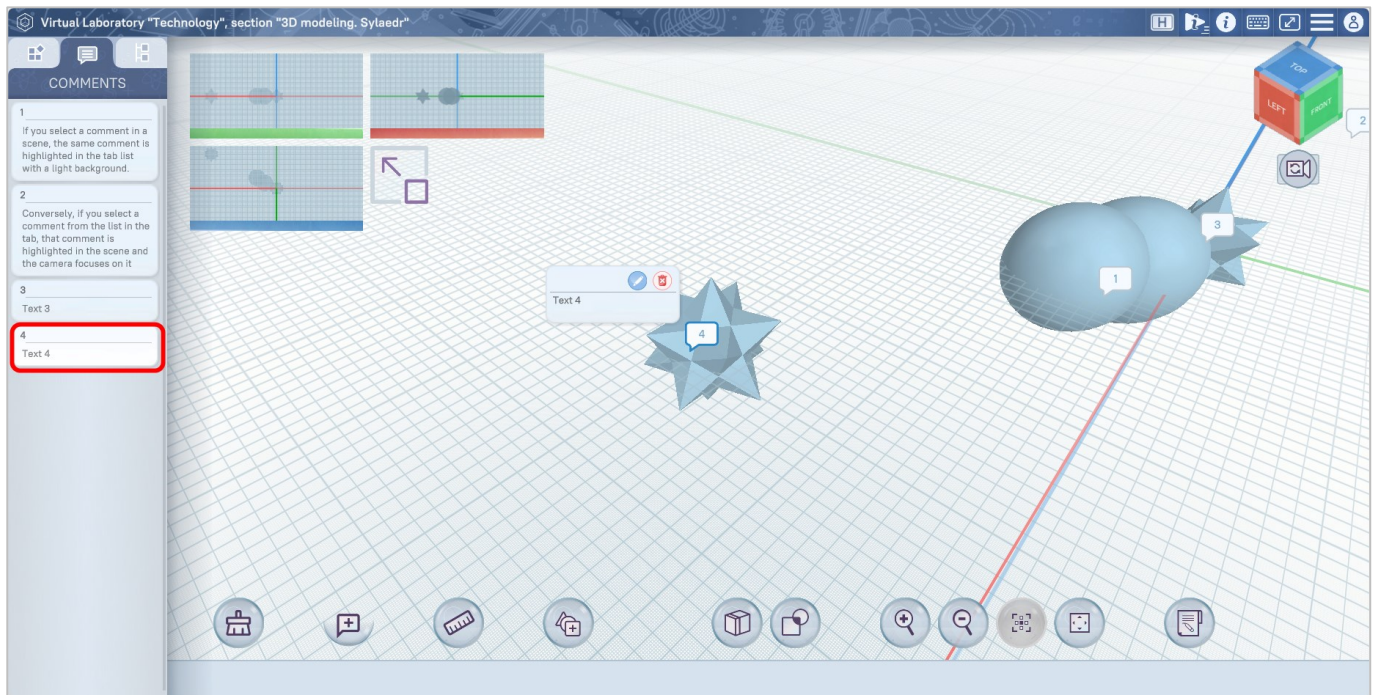


Figure 25 – Viewing a comment

The process of creating and editing comments is described in section [2.4.2 Creating and editing comments in a scene](#).

2.3.3 List of Objects tab

Click on the **List of Objects** tab shortcut to view a list of all objects that are in the current scene (Figure 26). The list displays the names of objects and, if there are several objects of the same type, then their serial numbers are also displayed.

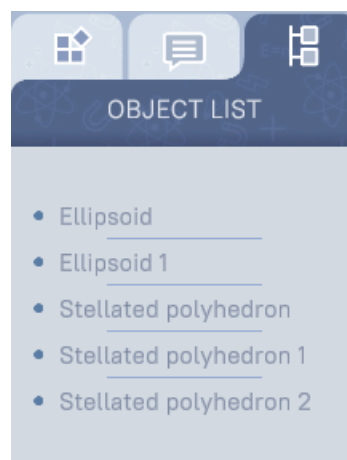


Figure 26 –List of Objects tab

If you select an object in the scene, the same object is highlighted in the list on the tab with a light background. Conversely, if you select an object from the list on the tab, that object is highlighted in the scene. Using this list you can select objects that are not currently visible on the screen (Figure 27).

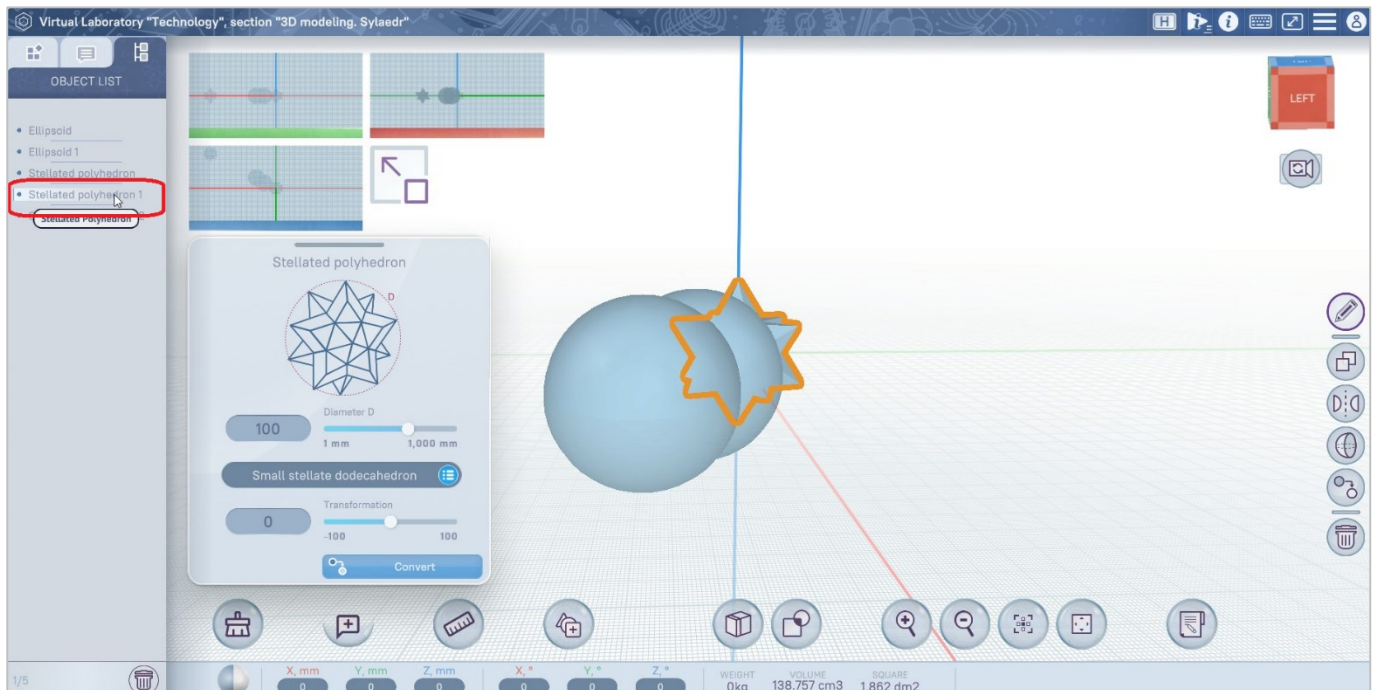


Figure 27 – Selecting an object through the list

You can simultaneously select several objects in the list by holding down the Shift key.

If there is at least one selected object in the list, a  button is displayed at the bottom of the tab to delete selected objects from the list and from the scene.

2.4 Control panel

2.4.1 Control panel elements



Figure 28 – Control panel

Control panel (Figure 28) is located at the bottom of the work area and contains the following elements:

- **Clear Scene** button  (see [3.4 Deleting objects](#));
- **Comments** pull-out element  (see [2.4.2 Creating and editing comments in a scene](#));
- toggle-button for the **Digital Ruler** tool  (see [2.4.3 Digital Ruler](#));
- toggle-button for the **Multiple Selection** tool  (see [2.4.4 Multiple Selection](#));

- toggle-button for the **Spline** tool . The button is only displayed when switching to one of the orthogonal views (see [3.6 Spline](#));
- toggle-button for the **Kinematic Operations** tool . When you click the button, the tool settings panel is displayed (see [3.7 Kinematic Operations](#));
- toggle-button for the **Boolean Operations** tool . When you click the button, the tool settings panel is displayed (see [3.8 Boolean Operations](#));
- camera control buttons: **Zoom In** , **Zoom Out** , **Focus on Object**  and **Show the Entire Scene**  (see [4.3 Camera control buttons](#));
- toggle-button for the **Scene Card**  (see [2.4.5 Scene Card](#)).

2.4.2 Creating and editing comments in a scene

To create a comment, drag the button  on the control panel and type the comment you are creating in the scene — on a figure or in the work area (Figure 29).

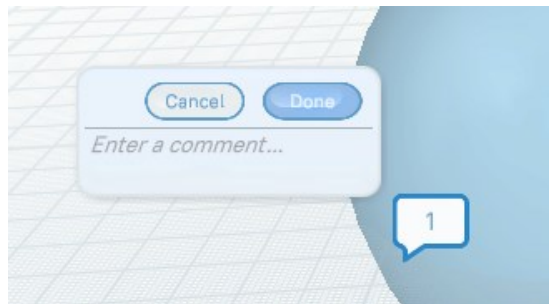


Figure 29 – Creating a comment

Enter the text of the comment and click the **Done** button. To cancel the creation of a comment, click the **Cancel** button.

When you click on a created comment, a window with a description of the comment opens (Figure 30) as well as the buttons for editing  or deleting it .

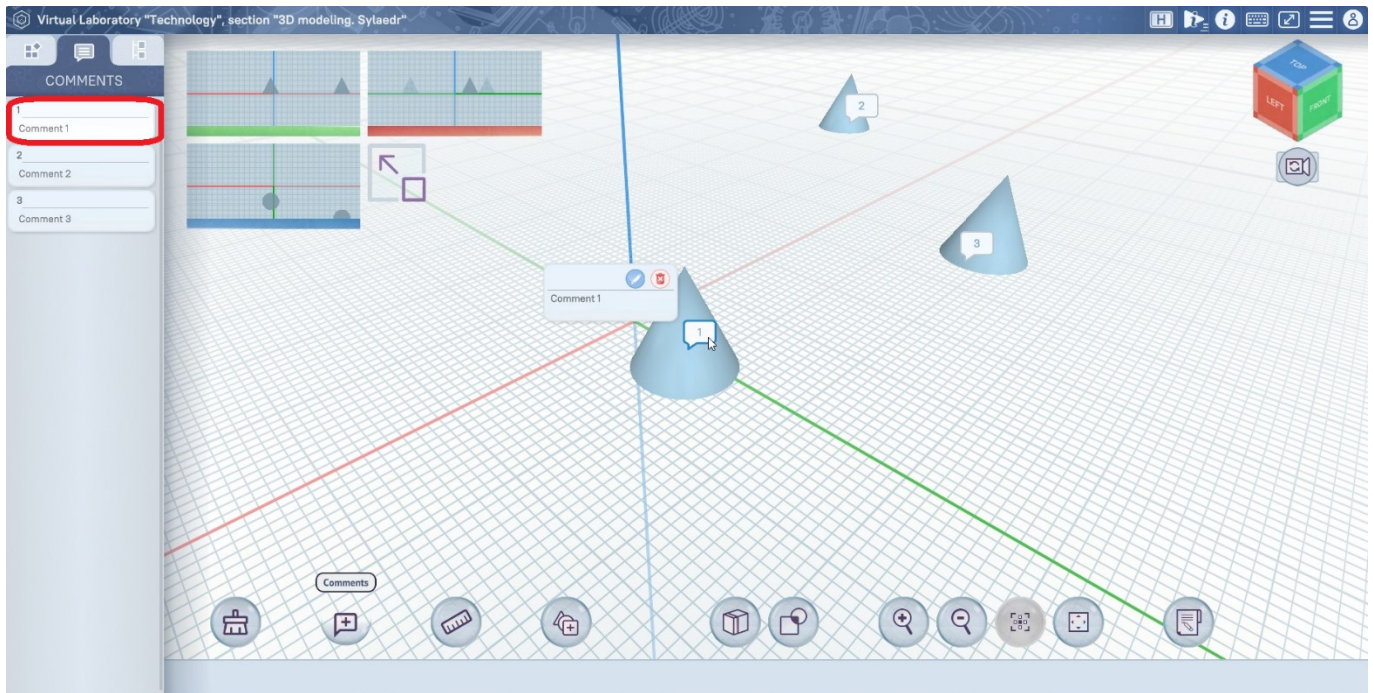


Figure 30 – Viewing a comment

All comments created in the scene can be viewed as a list on the **Comments** tab (see [2.3.2 Comments tab](#)). When you click on a comment in the list, the camera focuses on the area of the scene in which that comment is located.

2.4.3 Digital Ruler

The **Digital Ruler** tool (Figure 31) represents a straight line between two points in the scene (points of a figure, plane, grid, space) and allows you to measure the distance between them. The distance value in millimeters is displayed next to the ruler.

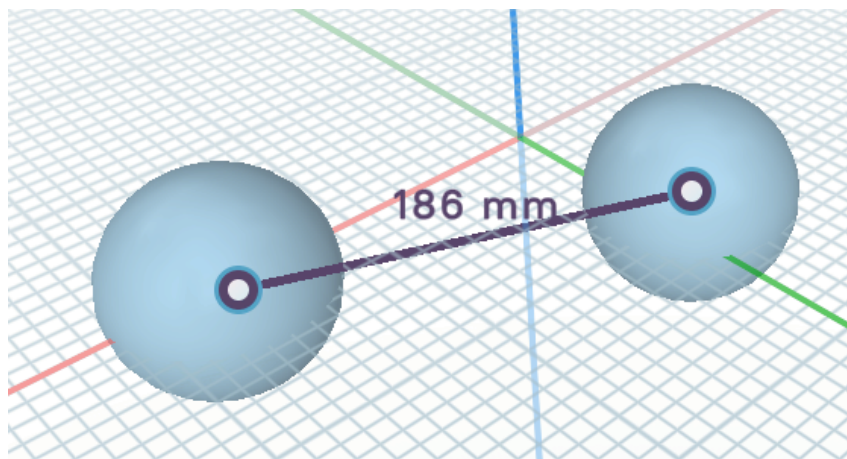


Figure 31 – Digital Ruler

The tool is turned on using the  button on the control panel. To measure the distance, click on those points in the work area where you want to set the beginning and the end of the ruler. The ends of the ruler can be moved by pulling them. To delete a ruler, click on it and then click on the  button at the right edge of the work area.

2.4.4 Multiple Selection

Multiple Selection is a tool for selecting multiple objects in a scene. The tool is activated by the  button on the control panel. Also, the tool is always active when the Shift key on the keyboard is held down.

When the **Multiple Selection** tool is enabled, you can select multiple objects in two ways:

- by rectangular frame. All unselected objects that fall inside the frame will be selected (Figure 32). And if selected objects fall inside the frame, then the selection from them is removed.

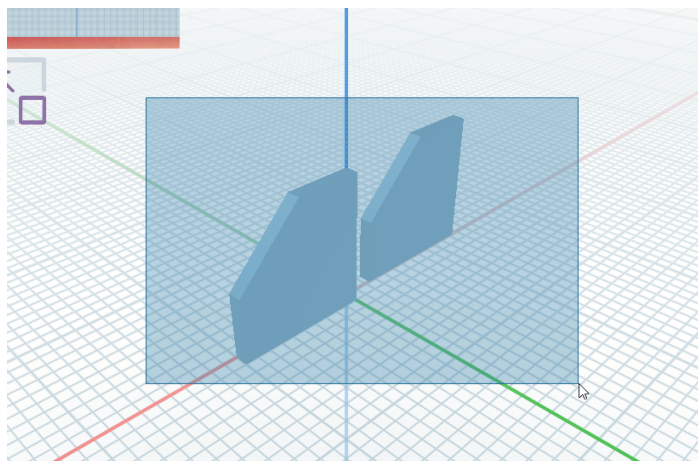


Figure 32 – Selecting objects with a frame

- by clicking on each unselected object. When you click on a selected object, the selection is removed from it.

One set of Gizmo manipulators is displayed for all selected objects (see [2.9 GIZMO manipulators](#)) in their common pivot (Figure 33).

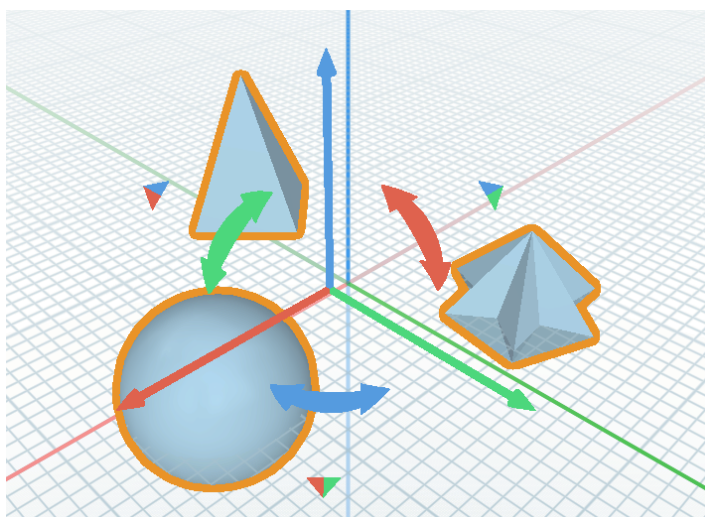


Figure 33 –Gizmo for selected objects

2.4.5 Scene Card

Scene card (Figure 34) allows you to fill in and view the information about the scene that will be required when saving it.



Figure 34 – Scene card

Scene cards is opened:

- when you click on the **Scene Card** button  on the control panel (Figure 28);
- when saving a scene or a copy of it (see [2.2.6.1 Saving the scene](#) и [2.2.6.2 Saving a scene copy](#));
- when selecting a scene in the **My scenes** library (see [2.2.6.4 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 34).

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 [2.2.4 Virtual Keyboard](#) and [2.2.6.1 Saving the scene](#).

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

2.5 Orthogonal views panel

Switching between perspective and orthogonal views is done using the orthogonal views panel (1) and the minimized perspective view window (2) (Figure 35).

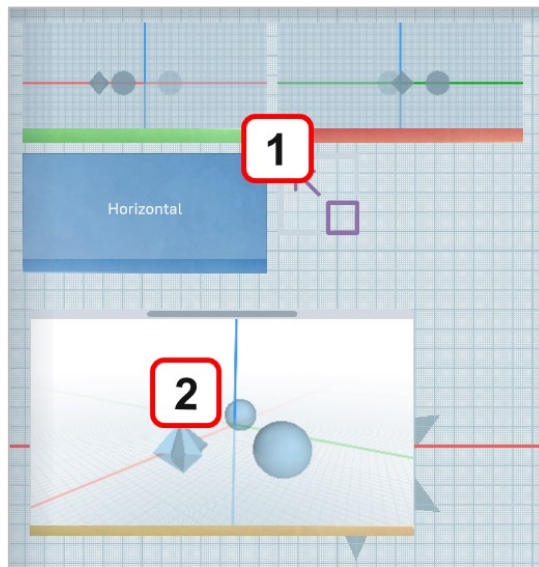


Figure 35 – Orthogonal views panel and minimized perspective view window

Orthogonal views panel has a minimized (compact) and expanded mode. Minimized panel has the following buttons (Figure 36):

- — to switch to frontal view (front), to the XZ plane;
- — to go to the profile view (left), to the YZ plane;
- — to switch to horizontal view (top), to the XY plane;
- **Expand** — the panel expands to view all three views.



Figure 36 – Minimized orthogonal views panel

When expanded (Figure 37), the panel contains three small windows, each of which displays a corresponding view of the scene, and a **Minimize** button, which minimizes the panel to a compact view.

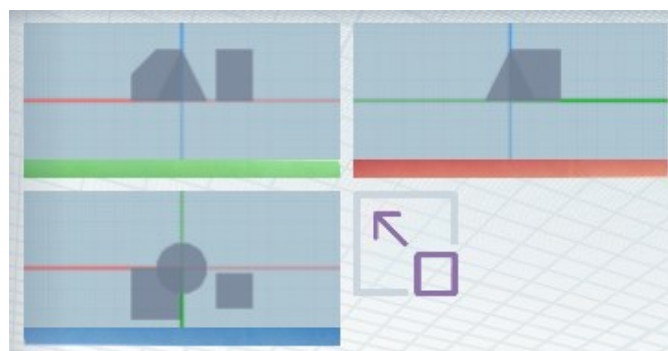


Figure 37 – Expanded orthogonal views panel. Perspective view is active

If perspective view is active, then all three windows display orthogonal views of the current state of the scene (Figure 37). By changing the position and shape of shapes in the scene, you can simultaneously observe how these changes appear in each orthogonal view. To go to a specific orthogonal view (expand it to the entire work area), click on the button (in minimized mode) or on the window (in expanded mode) of this view in the orthogonal views panel.

If one of the orthogonal views is active, then the name of the current active view is displayed in the corresponding window in the orthogonal views panel (Figure 35), and a **minimized perspective view window** is displayed in the scene (2, Figure 35). By clicking on this window, you can go to a perspective view of the scene. This window can be moved around the work area by clicking on it and then by dragging it by the pointer.

2.6 Shape settings panel

The shape settings panel is displayed for the selected parametric shape in parametric editing mode (see [3.3.1 Parametric editing](#)). In this panel, you can view the current shape settings and change them.

The settings panel contains an image of the shape, elements for setting its parameters, and a

 **Convert** button (Figure 38).



Figure 38 – Settings panel example

To set the shape parameters, enter the parameter value in the input field (1) or drag the slider (2) to the left or the right. To choose a parameter value from the list, click the icon  (3) and select the desired option from the drop-down list.



Figure 39 – Ellipsoid settings panel

The  **Convert** button serves to complete parametric editing of a figure. After clicking this button (i.e. for a **converted** shape), the settings panel will no longer be available.

The settings panel can be moved around the workspace by holding the pointer on the top edge of the panel and then dragging it.

2.7 Properties panel

Properties of a figure are coordinates (angular and linear), material and quantitative characteristics of the figure. Coordinates and materials are editable parameters, while quantitative characteristics are informational and cannot be edited.

Properties are displayed in the properties panel (Figure 40) at the bottom of the work area, under the control panel, if there is a selected object (or several objects) in the scene.



Figure 40 – Properties panel

2.7.1 Shape Material

For a selected 3D shape, the **Shape Material** button appears on the left side of the properties panel (Figure 40).



*The **Shape Material** button is not displayed for a 2D shape or for a selected group of objects.*

By default, all 3D shapes are created without material (therefore, they have no defined mass, and it is displayed as "0 kg") and their button looks like: . When pressing the  button the material selection panel is displayed (Figure 41).



Figure 41 – Material selection panel

After selecting a material, the appearance of the button and the appearance of the shape in the scene change in accordance with the selected material. Each material has a corresponding density, the value of which is used to calculate the mass of the figure. The materials panel can be hidden by clicking outside of it.

2.7.2 Shape coordinates

The properties panel (Figure 40) displays the linear and angular coordinates of the pivot of the object selected in the scene. For a selected group of objects, only linear coordinates of the group pivot are displayed; angular coordinates are not displayed.



A pivot is the geometric center of one figure or a point whose coordinates are determined as the average values of the corresponding coordinates of the geometric centers of several figures.

By moving an object in the scene, you can track changes in its coordinates in the properties panel. You can also change the position of an object in the scene by manually changing its coordinates.

The coordinates are displayed in editable input fields:

- for a 3D figure — three input fields for linear and three input fields for angular coordinates: X, Y, Z (Figure 42);

X, mm	Y, mm	Z, mm	X, °	Y, °	Z, °
30	-233	35	33	346	275

Figure 42 – 3D shape coordinates

- for 2D shapes and splines — three linear input fields and one angular coordinate input field (Figure 43).

X, mm	Y, mm	Z, mm	X, °	Y, °	Z, °
24	50	32	-	-	310

Figure 43 – Coordinates of a 2D figure lying in the XY plane

The range of values that can be stored in the input field is:

- for linear coordinates: from 0 to ± 5000 mm;
- for angular coordinates: from 0° to $\pm 360^\circ$.



The set of available coordinates corresponds to the set of rotation and transition GIZMO manipulators available for an object (see 2.9 GIZMO manipulators).

For 2D shapes, you can change the linear coordinates X, Y, Z and the following angular coordinates:

- for 2D figures lying in a plane parallel to the XY plane — angular Z;
- for 2D figures lying in a plane parallel to the XZ plane — angular Y;
- for 2D figures lying in a plane parallel to the YZ plane — angular X.

The remaining two angular coordinates are not editable and are indicated by a dash (Figure 43). For example, a 2D shape lying in a plane parallel to the XY plane cannot be rotated outside of that plane, so the X and Z angular coordinates are not editable.

For a point, only linear coordinates are available in the plane in which the spline lies. The third linear coordinate is displayed but it is not editable.

2.7.3 Quantitative characteristics of the figure

On the right, the properties panel displays the characteristics that the shape selected in the scene has.



For the selected group of objects, quantitative characteristics are not displayed.

Quantitative characteristics of a 3D figure (Figure 44):

WEIGHT	VOLUME	SQUARE	SHELL
0.604kg	31.298 cm ³	6.359 dm ²	

Figure 44 – Quantitative characteristics of a 3D figure

- **mass** is displayed only for a figure with a given material. The mass of an object is defined as the product of the volume and density of the substance;
- **volume**;
- **surface area**. For the shell, the sum of the areas of the outer and inner surfaces is calculated;
- if the shape is a shell, the text **SHELL** is displayed.

Quantitative characteristics of a 2D figure:

- **perimeter** and **area** are displayed for a 2D shape and for a closed contour (spline);
- **the contour length** is displayed only for an open contour (spline).

When changing the parameters and material of the figure, the characteristics are recalculated automatically.

2.8 Context menu

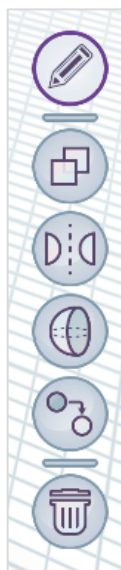


Figure 45 – Context menu

The context menu (Figure 45) is displayed at the right edge of the workspace provided that at least one object is selected in the scene. The menu contains a set of buttons for calling up tools and switching modes available for the selected objects. The composition of the buttons in the menu depends on the type of object in the scene, its mode and also on whether one or several objects are selected.

A list of all buttons that can be displayed in the context menu is presented in the Table 1.

Таблица 1 – Context menu buttons

Type	Name	Purpose
	Edit	Enable/disable the editing mode. When editing mode is enabled (the button in the active state changes color: ): – Gizmo manipulators are hidden (see 2.9 GIZMO manipulators); – the settings panel is displayed for the selected parametric shape; – for the selected object, the composition of the buttons in the context menu changes. For example, for a spline, Add a point  and Continue a spline  buttons are displayed; – the selection of points becomes available for the spline. The button is not displayed for converted 3D shapes, spline points, or when multiple shapes are selected
	Delete	Deleting the selected object, hiding the context menu (see 3.4 Deleting objects)
	Copy	Creating a new shape that is a copy of the selected shape (see 3.9 Copy). The button is not displayed for a point or a spline in the edit mode
	Reflection	Create a new shape that is a reflection of the selected one (see 3.10 Reflection). When pressed, the button goes into the active mode: . The button is not displayed for a point or a spline in the edit mode
	Create a shell	Create a shell of the selected shape (see 3.11 Shell). The button is displayed for all 3D objects except shells
	Convert	Convert a parametric 3D shape into a converted one. When you press the button, Gizmo manipulators are displayed.
	Convert into a spline	Converting a parametric 2D figure into a spline (see 3.6 Spline). Control points are displayed on the spline, and a set of buttons corresponding to the spline is displayed in the context menu

Type	Name	Purpose
Spline/Point context menu buttons		
	Add a point	Enabling the point adding mode. The button is displayed for a spline in the edit mode
	Continue a spline	Enable the spline creation mode. When you press the button, the last point of the spline is highlighted. The button is displayed for an open spline in the edit mode
   	Point type: – straightening point, – symmetrical controller, – asymmetrical controller, – fractured controller	Changing the point type and curve shape. For a curvature point, the curvature controllers are changed. Buttons are displayed for the highlighted control point. For one selected point, only one button can be active
	Rounding / cutting	Enable Rounding/Cutting Off mode. When you click this button, only the Complete button  appears in the context menu. The button is displayed for the selected control point
	Finish	Exiting the current mode: – creating a spline; – adding points to the spline; – cutting/rounding. The button is displayed: – for a spline in the mode of creating, continuing and adding points; – for a point in cutting/rounding mode

2.9 GIZMO manipulators

GIZMO manipulators allows you to:

- rotate, move and scale a shape along three axes and in three planes when perspective view is active (Figure 46);
- rotate, move and scale a shape along two axes and one plane when the orthogonal view is active (Figure 47);
- perform proportional scaling.

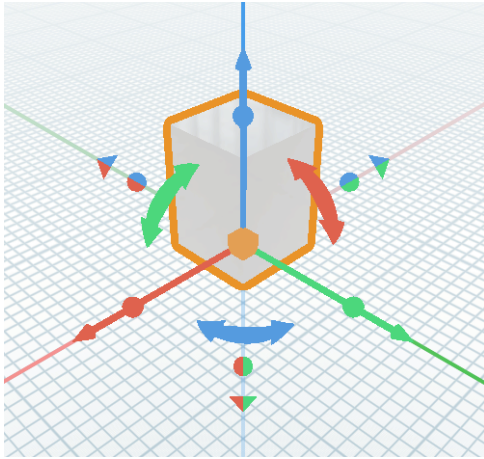


Figure 46 – GIZMO manipulators.
Perspective view

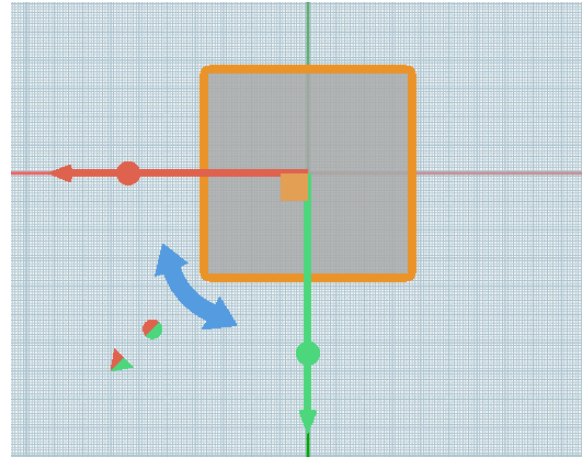


Figure 47 – GIZMO manipulators.
Orthogonal view

To have Gizmos displayed for an object:

- if the object is a parametric figure or a spline, select this object and turn off the editing mode for it with the  button in the context menu;
- if the object is a converted 3D shape, select this object.

The axes of the manipulators are directed in the same way as the coordinate axes of the scene (Figure 46).

The center of Gizmo (the point of intersection of the three axes of the manipulators) lies in the pivot of the figure. If several shapes are selected, then the center of Gizmo is located in their common pivot.

2.9.1 Manipulator colors

The colors of the manipulators correspond to the colors of the axes along or around which they "work" (move, rotate or scale an object): blue — Z axis, green — Y axis, red — X axis.

Two colors of the manipulator mean that the manipulator operates in the corresponding plane. For example, a red-green manipulator  serves to move an object in a plane parallel to the XY plane.

2.9.2 Manipulators shapes

The shape of GIZMO manipulators depends on their purpose (Figure 48):

- arrow — movement type:
 - single color  — movement along the axis;
 - two colors  — movement in a plane;

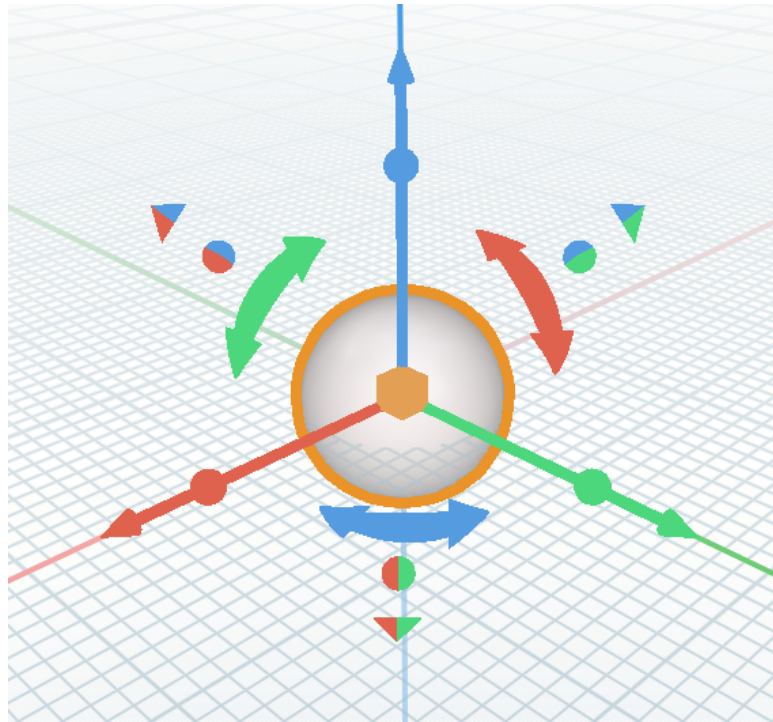


Figure 48 – Form and purpose of the manipulators

- ball (displayed only for the spline and for converted 3D shapes outside editing mode) — scaling:
 - single color  — along one axis;
 - two colors  — along two axes;
- double-headed arrow  — rotation around an axis;
- cube in the center  (only visible for converted 3D shapes) — proportional scaling.

2.9.3 Interactions with manipulators

When you interact with a manipulator (rotating, moving, or scaling), all manipulators except the active one are hidden, and the active manipulator increases in size.

2.9.3.1 Moving a shape

When moving a figure behind the manipulator along the axis, the corresponding coordinate of the center of the figure changes. For example, if you pull the red arrow , the X coordinate of the figure's center changes. When moving behind the manipulator on the plane, the value of the two corresponding coordinates changes by the same amount. For example, if you pull the red-green arrow , the X and Y coordinates change by an equal amount (Figure 49).

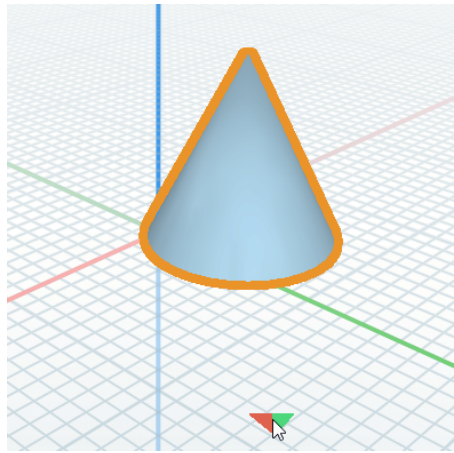


Figure 49 – Moving a shape in the XY plane

Changes in coordinate values can be tracked in the properties panel (Figure 50).



Figure 50 – Changing coordinates in the properties panel when moving a shape in the XY plane

2.9.3.2 Rotating a figure

When rotating behind the manipulator using the double-headed arrow, the figure rotates around the corresponding axis passing through the figure's pivot. So, using the blue manipulator, the figure rotates around the Z axis (Figure 51).

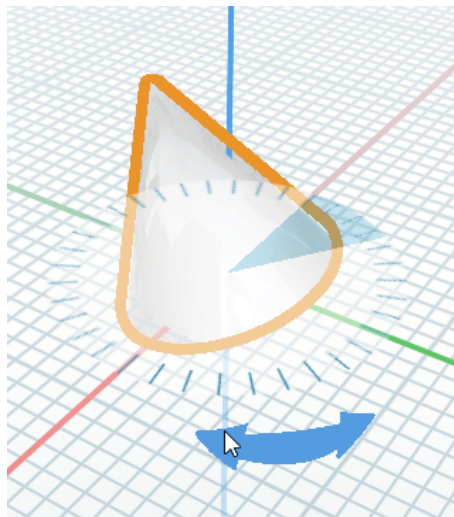


Figure 51 – Rotating a figure around the Z axis

In this case, during rotation, all Gizmo manipulators, except for the selected rotation manipulator, are hidden and the current angle of rotation is displayed in the plane perpendicular to the selected manipulator.

Changes in coordinate values can be tracked in the properties panel (Figure 52).



Figure 52 – Changing the coordinate in the properties panel when rotating a figure around the Z axis

2.9.3.3 Scaling a shape



The scaling operation is only available for converted 3D shapes and for splines outside of the edit mode.

When scaling disproportionately (along an axis or in a plane), the size of the figure changes along the corresponding axis or along two axes at once in both directions relative to the pivot. So, if you pull the red ball , the size of the figure will change along the X axis, and if you pull the red-green ball , then the size of the figure will change along the X and Y axes.

When scaling a 3D figure proportionally (to do this, click on the cube with the pointer  and pull) the size of the figure changes proportionally relative to the pivot along each of the three axes in perspective view and along each of the two axes in orthogonal view.

3 Creating and editing shapes

3.1 Creating a shape

You can create a figure in the Virtual Laboratory in the following ways:

- take it from the library of shapes (see description below);
- create a 2D contour using a spline (see [3.6 Spline](#));
- using kinematic operations (see [3.7 Kinematic Operations](#)) and boolean operations (see [3.8 Boolean Operations](#)).

You can add a shape to the scene from the shape library (see [2.3.1 Shapes tab](#)) in one of two ways:

- by clicking on the shape card (see [3.1.1 Creating a shape by clicking](#));
- by clicking on the card and dragging it into the work area (see [3.1.2 Creating a shape by elongation](#)).

The shape is created selected and with default parameters. If there are already selected shapes in the scene at the time of creating a new figure, the selection is removed from them.

After creating a figure, **parametric editing** mode is available for it (that is, its parameters can be edited in the figure settings panel). We will call such a figure **parametric**. To finally complete the parametric editing mode, you need to:

- if this is a 3D figure, then convert it. For the **converted** 3D figure, editing parameters will no longer be available, but the **scaling editing** mode will work. The scene can contain both parametric and converted shapes at the same time;
- if this is a 2D figure, then convert it to a spline. For a 2D shape **converted to a spline**, the **scaling editing** mode will be available, but in addition, selecting spline control points and editing them will be available.

For more information about parametric and converted shapes, see [3.3 Editing a shape](#).

3.1.1 Creating a shape by clicking

Click on the shape card in the shape library (Figure 22, Figure 23) — the corresponding figure will appear in the scene.

When creating a 3D shape, depending on which shape was selected, its base (Figure 53) or its center lies in the XY plane.

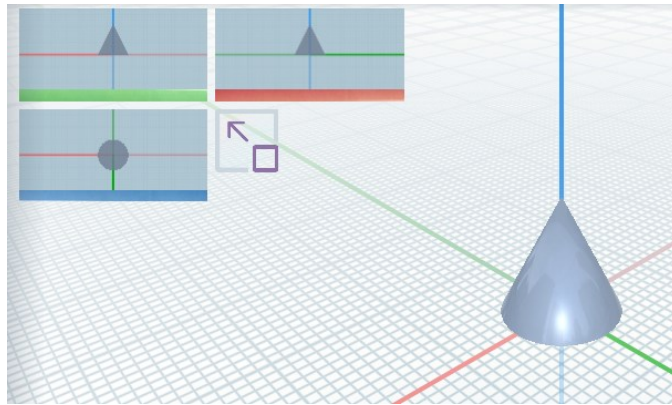


Figure 53 – Creating a 3D shape by clicking

When creating a 2D shape:

- if perspective view is active, the created 2D shape will lie in the XY plane (Figure 54);

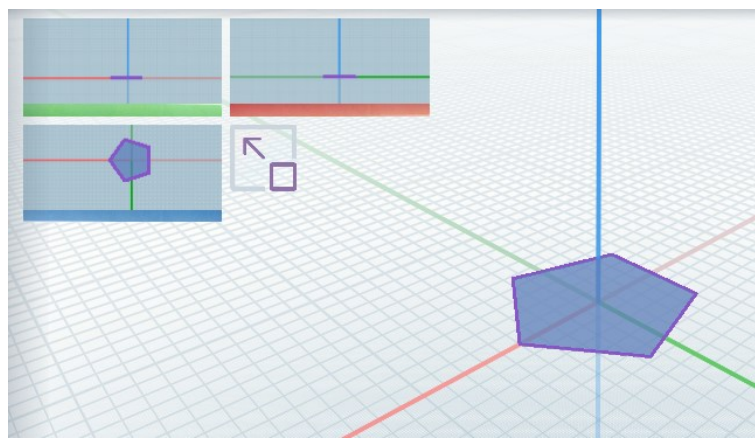


Figure 54 – Creating a 2D Shape by Clicking. Perspective View

- if the orthogonal view is active, then the created 2D shape will lie in the plane whose window is currently active. For example, if the front view was active when the shape was created, the 2D shape will be created in the XZ plane (Figure 55).

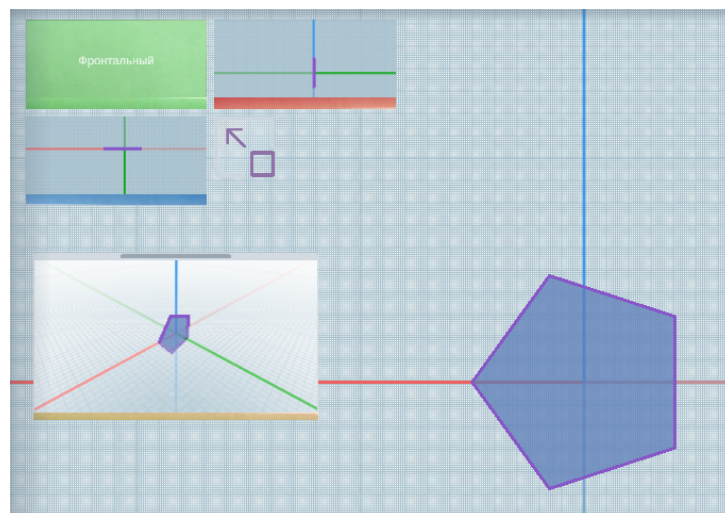


Figure 55 – Creating a 2D shape by clicking. Frontal view

3.1.2 Creating a shape by elongation

Click on the card of the desired shape in the shape library (Figure 22, Figure 23), drag and release the pointer at the location on the workspace where you want to create the shape.

Once you've pulled a 3D shape from the library, you can move it around the scene in the XY plane (both orthogonal and perspective). Shapes that have a base (for example: cylinder, cone, prism) are created so that their base lies on the XY plane (Figure 56), and shapes that do not have a base (for example: a ball, a torus) are created so that their center lies on the XY plane (Figure 57).

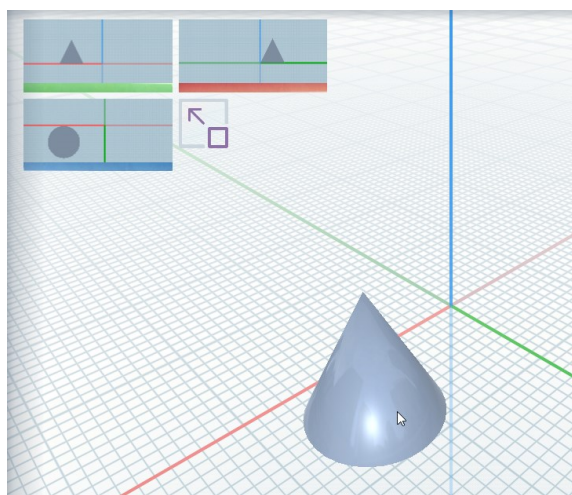


Figure 56 – The base of the created cone lies on the XY plane

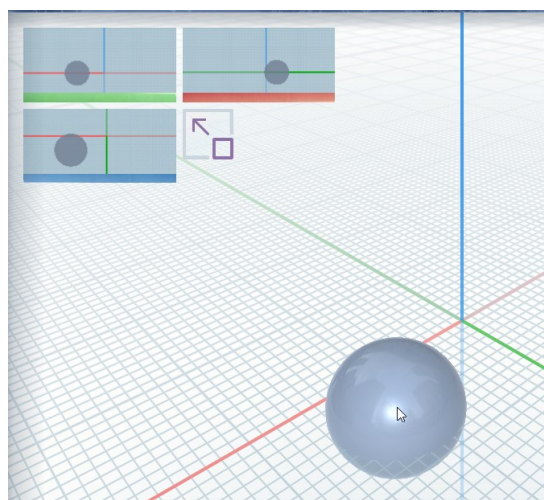


Figure 57 – The center of the ball lies on the XY plane

By pulling a 2D shape from the library, you can move it around the scene:

- in perspective view — in the XY plane (Figure 58);

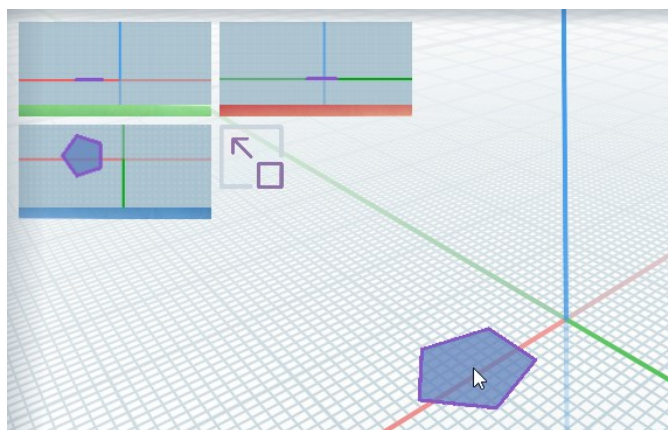


Figure 58 – Creating a 2D shape in the XY plane by elongation

- in orthogonal form — in the plane whose window is currently active. For example, if the front view was active when creating a shape, then the created 2D shape can be moved in the XZ plane (Figure 59).

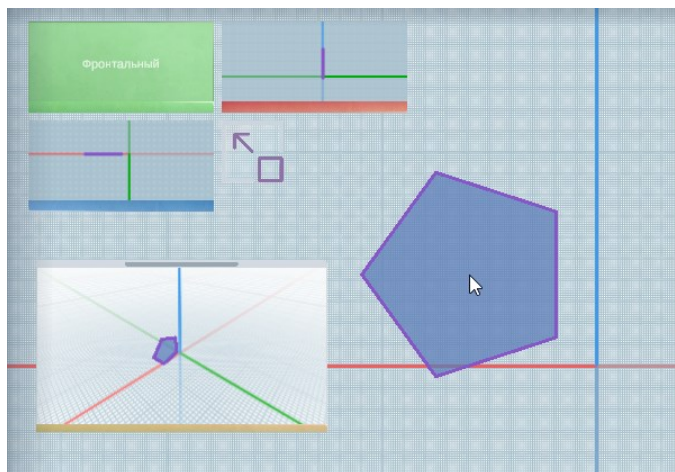


Figure 59 – Creating a 2D shape in the XZ plane by elongation

3.2 Selecting (highlighting) objects in the scene

To select one object (3D shape, 2D shape, or an outline), click on it with the pointer.

You can select multiple objects when using a mouse/touchpad and a keyboard:

- with a rectangular frame using the right mouse/touchpad button (Figure 32). All objects that fall completely inside the frame will be selected;
- with a frame, using the left mouse/touchpad button while holding down the Shift key;
- with a left-click on the mouse/touchpad while holding down the Shift key;
- by using the **Multiple Selection** tool (see [2.4.4 Multiple Selection](#)), which allows you to select both with a frame and by clicking on individual objects (analogous to selecting while holding down the Shift key).

To deselect:

- click in a place in the scene empty of objects — all selected objects will be deselected. When performing a Boolean operation: if the subtrahend selection is active, all subtrahends will be deselected, and the selected minuend will remain selected;
- click on the selected object while pressing the Shift key — the selection will be removed from this object;
- click on the selected object with the **Multiple Selection** tool enabled — the selection will be removed from this object.

3.3 Editing a shape

A shape created from the library is in **parametric editing mode** (see [3.3.1 Parametric editing](#)), which allows you to set its precise parameters in the settings panel. Such shapes for which editing of parameters (or parametric editing) is available will be called **parametric**.

3.3.1 Parametric editing

Editing mode for a parametric shape can be turned on or off with the **Edit** button  /  in the context menu (this button for a parametric figure is always displayed in the context menu). Accordingly, the selected parametric figure can be in one of two states:

- in editing mode (Figure 60, Figure 61). The shape settings panel is shown (see [2.6 Shape settings panel](#)), the **Edit** button in the context menu is active: ;

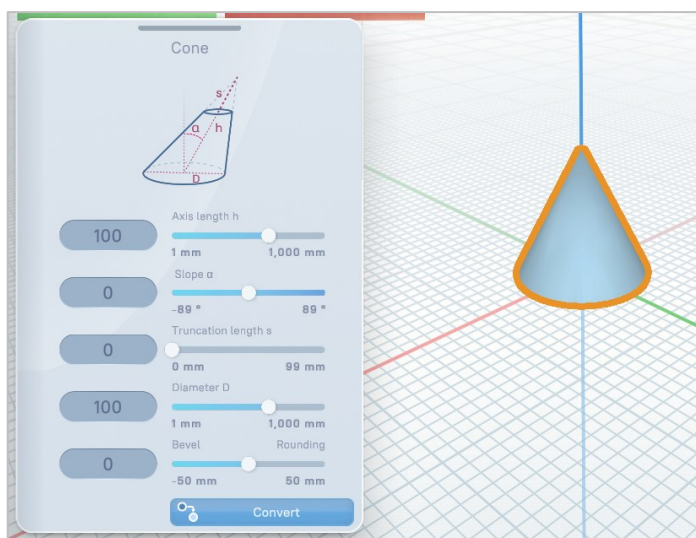


Figure 60 – Parametric shape in edit mode.
Perspective view

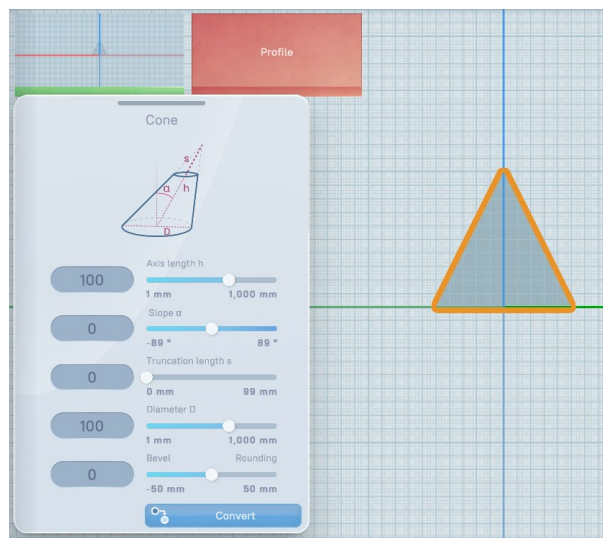


Figure 61 – Parametric figure in edit mode.
Profile view

- in Gizmo mode, when editing mode is turned off (Figure 62, Figure 63). Then the GIZMO transition and rotation manipulators are displayed — the shape can be moved and rotated. But the shape cannot be scaled until it is converted or turned into a spline, so the scaling Gizmos do not appear (see [2.9 GIZMO manipulators](#)). The **Edit** button in the context menu is inactive: .

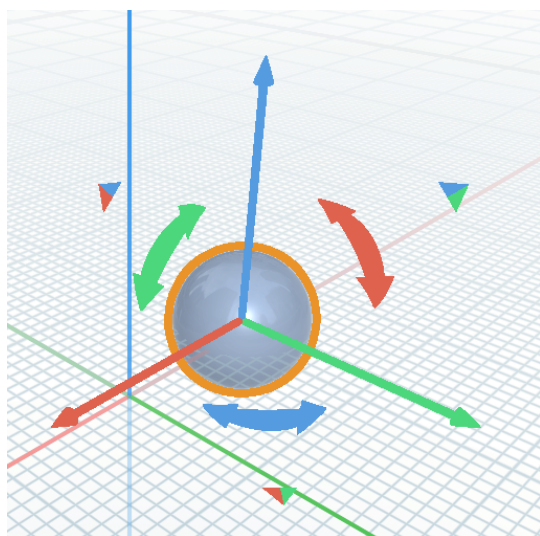


Figure 62 – Parametric shape in Gizmo mode.
Perspective view

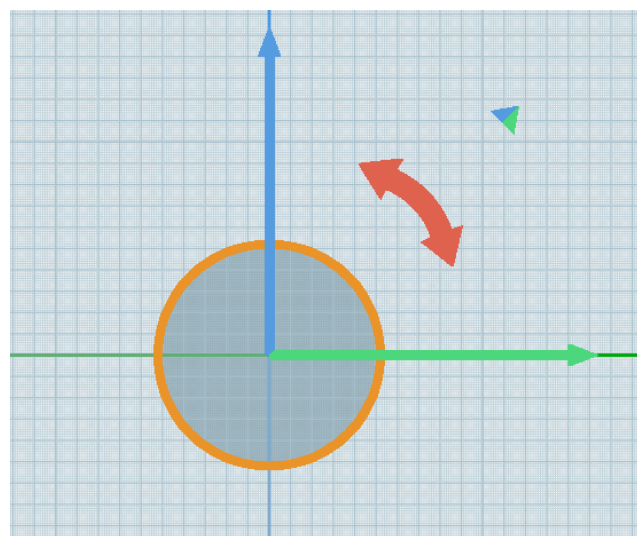


Figure 63 – Parametric shape in Gizmo mode.
Horizontal view

To edit shape settings:

- 1) If the shape is not selected, select it.
- 2) If the editing mode is turned off (GIZMOs are displayed), turn it on by clicking the  button in the context menu.
- 3) On the settings panel (Figure 60, Figure 61) click on the field of the desired parameter. A text cursor for editing the value will appear in the field (Figure 64). Edit the value and confirm the entry by clicking anywhere on the workspace outside the input field.

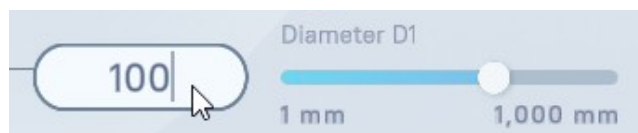


Figure 64 – Entering a parameter value



The sphere/ellipsoid constructor has a button to turn on/off the Sphere mode  (Figure 39). In this mode, all diameters are equal and change synchronously when the value of any diameter changes.

- 4) Edit other parameters in the input fields or in the drop-down lists (using the button ).

3.3.2 Converting and transforming a shape

3.3.2.1 Converting 3D shapes

For a 3D shape, parametric editing mode is available until it is completed by converting the shape.

To do this, select the shape and click the button  on the settings panel or the  button in the context menu. After this, you will receive a **converted** figure, for which editing by scaling is available. In the scene, parametric 3D shapes are colored gray until a material is selected for them. Converted 3D shapes are colored light gray (Figure 65).

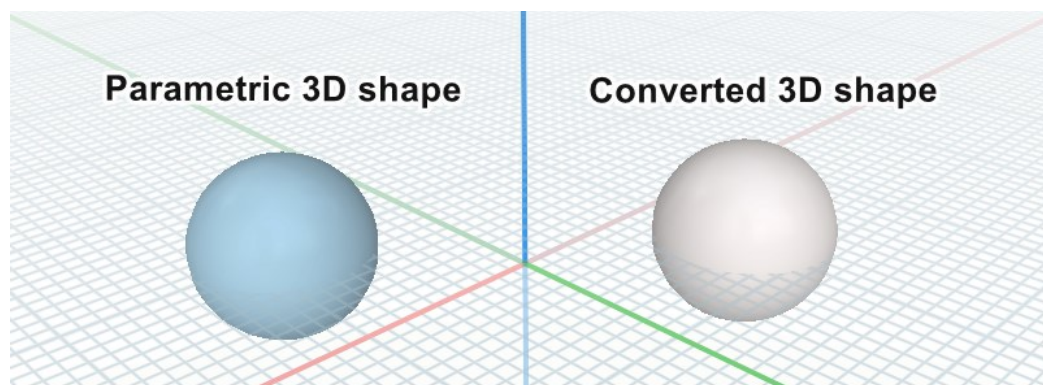


Figure 65 – Parametric and converted 3D shapes

3.3.2.2 Converting a 2D shape into a spline

For a 2D shape, parametric editing mode is available until it is completed by shapes's conversion into a spline. After this, you will receive a spline which you can edit by scaling. You will also select and edit the control points of the spline.

In the scene, 2D shapes converted to splines differ from parametric shapes which, then selected, display spline control points (Figure 66).

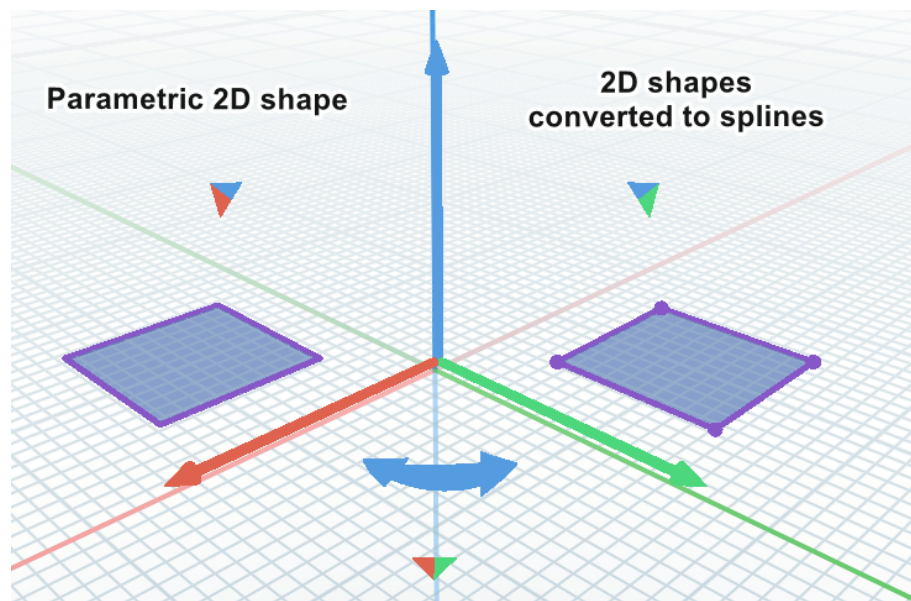


Figure 66 – Selected 2D shapes — parametric and converted into spline

3.3.3 Editing by scaling

Scaling editing (proportional and non-proportional) is available for converted 3D shapes and spline-converted 2D shapes and is performed using Gizmo handles (see [2.9.3.3 Scaling a shape](#)).

3.4 Deleting objects

To delete one or more objects in the scene, select them and press the  button in the context menu or the **Delete** key on the keyboard.

If you want to delete all objects in the scene, click the  button on the control panel, and then the **Delete all objects** button in the confirmation window (Figure 67).

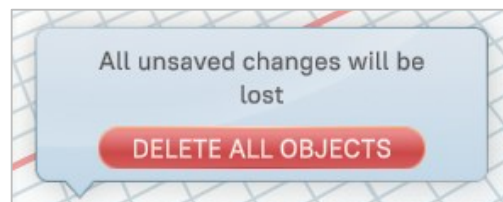


Figure 67 – Confirmation of the scene's clearance window

3.5 Function graph

3.5.1 Creating a graph

The graph is a fractured line connecting points $(x, f(x))$ in the plane:

- XY — by default;

- XZ, if frontal view is active;
- YZ if profile view is active.



Figure 68 – Graph card

Create a graph in the same way the 2D shapes are created, using a card in the 2D shapes library (Figure 68):

- by clicking on the card, a graph is created with the center at the origin of the scene coordinates (0, 0, 0);
- by pulling the graph card to the desired position in the scene.

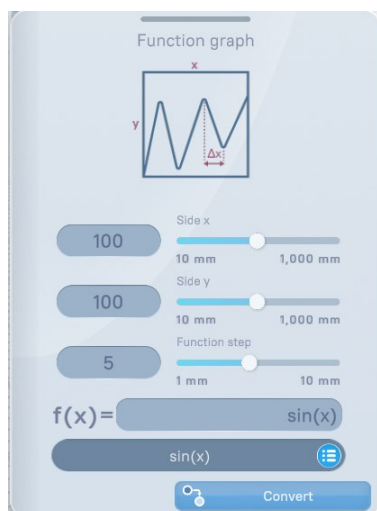


Figure 69 – Graph settings panel

The definition area and the range of values are limited by a square with sides x and y (Figure 69). The default x and y side lengths are 100 mm. They can be changed on the graph settings panel using the slider or by entering an integer from the keyboard in the input field (from 10 to 1000 mm).

The boundaries of the definition area and the range of values are measured as half of the x and y sides respectively from the center of the graph in each direction. Therefore, by default, when the center of the graph is the point (0, 0), the graph drawing is limited to the square (-50, 50) x (-50, 50).

The default step of the function is 5 mm. It can be changed with a slider from 1 to 10 mm or set as an integer in this range using the keyboard.



Figure 70 – Ready-made functions list

To plot a graph, you can set a ready-made function by clicking the  button on the settings panel and selecting a function from the list: x^2 , x^3 or $\sin(x)$ (Figure 70).

To set a function other than the options in the list, select Custom Function, or immediately start typing the formula in the field $f(x)=$  (Figure 71).

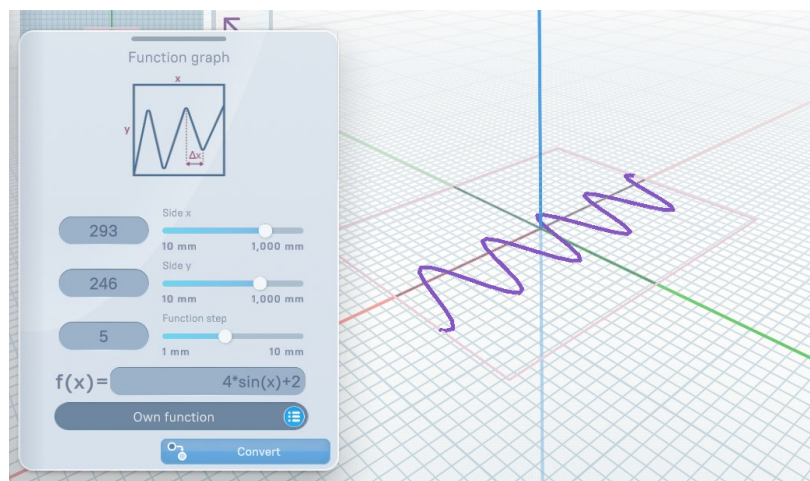


Figure 71 – Function graph

The formula allows numbers, parentheses "(" and ")", Latin letters, signs "+", "-", "*", "/" and "^" (spaces aren't important), as well as only one variable, which is denoted by the Latin letter x. You can also include the functions listed in the Table 2 in the formula.

Таблица 2 – Functions for graph plotting

Symbol	Name
abs	module
acos	arc cosine
arctg	arccotangent
asin	arcsine
atan	arctangent
cos	cosine
cosh	hyperbolic cosine
ceil	rounding up an argument
ctg	cotangent
exp	exponential value
floor	rounding down an argument
ln	logarithm
log	decimal (base 10) logarithm
sign	sign number indicating whether the number is negative, positive or zero
sin	sinus

Symbol	Name
sinh	hyperbolic sine
sqrt	square root
tan	tangent
tanh	hyperbolic arctangent

3.5.2 Moving a graph

To move the graph and the coordinates' origin within the plotting area turn the edit mode (the edit button must be active: ) , click inside this area and drag. The boundaries of the graph will not change, they will remain in place, but only the visible part of the graph will change.

In Gizmo mode (the edit button must be inactive: ) you can move the graph in the space of the work area using Gizmo manipulators, as well as any other shapes, and rotate the graph in the plane in which it is built (relative to its normal). You cannot change the scale until the graph is converted to a spline.

3.5.3 Converting graph into spline

To convert a graph to a spline, in the parameter editing mode (the editing button must be active: ) click the  **Convert** button on the graph settings panel (Figure 69) or the  button in the context menu. The fractured line will turn into a spline built on those points $(x, f(x))$ on which it was built as a graph (Figure 72).

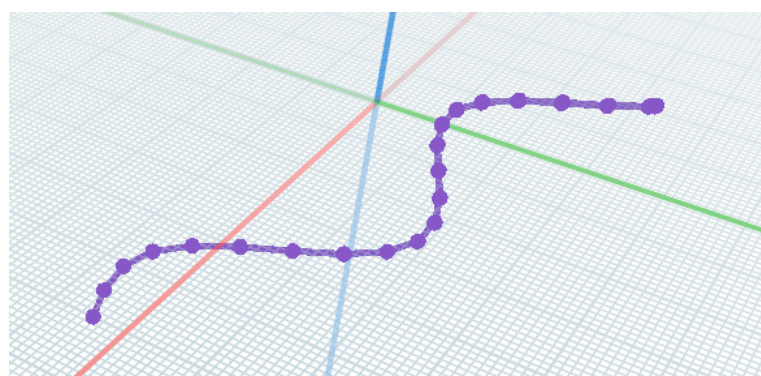


Figure 72 – Graph converted into spline

If there are discontinuities in the definition area, then a separate spline is created from each section of the function in which it is defined everywhere.

3.6 Spline

The **Spline** tool lets you create lines and contours made from straight and curved segments. The spline is constructed using control (bearing) points (Figure 73).

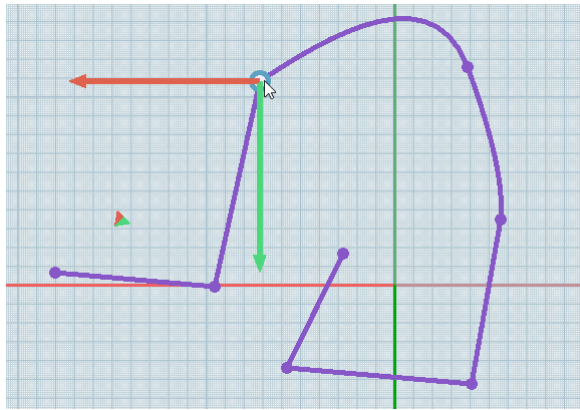


Figure 73 – Spline example

3.6.1 Spline elements

3.6.1.1 Checkpoints

Checkpoints can be of two types (Figure 74):

- **straightening point.** The segment following it can be straight if the next point is also straightening, and curved if the next point is bending. The segment between two straightening points is a straight line;
- **bending point.** Segments created before and after the bending point will always be curved.

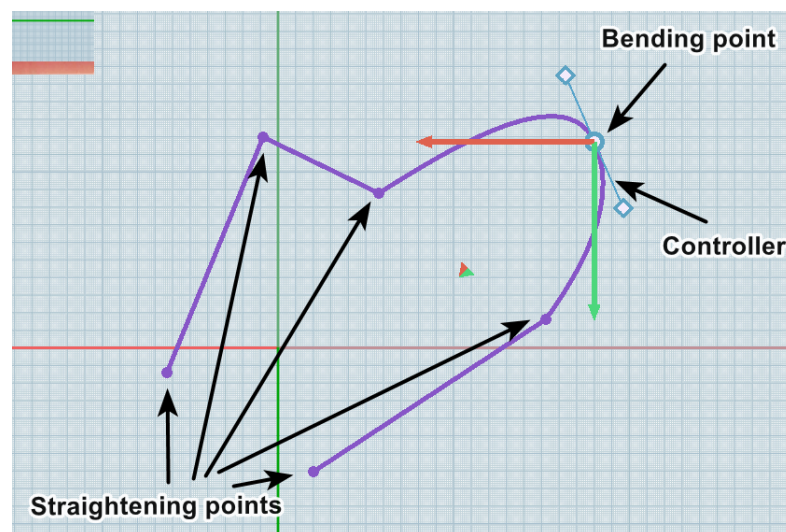


Figure 74 – Straightening and bending points of the spline

3.6.1.2 Controllers

The bending of segments can be controlled using controllers. **Controller** is a tool consisting of one (single-sided controller) or two (double-sided controller) straight segments drawn from a bending control point, with a control marker at the end  (Figure 74). For the straightening point, the controller is not displayed. Each part of the controller affects the shape of the segment on the corresponding side of the control point.

The one-way controller has the first and last (created) spline points if they are bending (Figure 75).

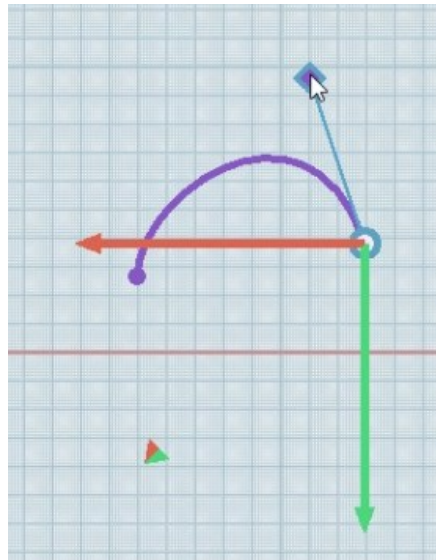


Figure 75 – One-way controller

The two-way controller has all the bending points except the first and the last (created) ones. The two-way controller can be:

- **symmetrical** (Figure 76). The control point and two markers always lie on the same straight line. If you pull the marker of one part of the controller, the second will change symmetrically to the first. The shape of both segments adjacent to this control point will change accordingly. This controller type is enabled by default for a new point (the last point of a spline or an additional point added);

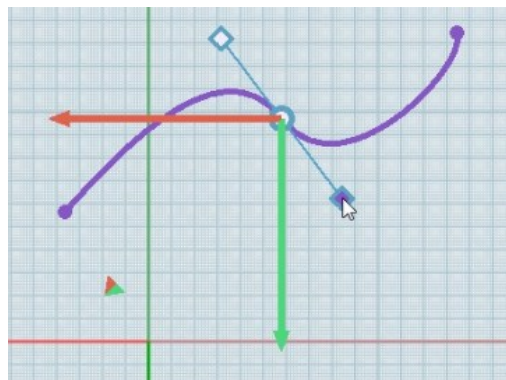


Figure 76 – Symmetrical controller

- **asymmetrical** (Figure 77). The control point and two markers always lie on the same straight line. If you pull the marker of one part of the controller, only the length of this part will change, while the second marker will remain in line with the first;

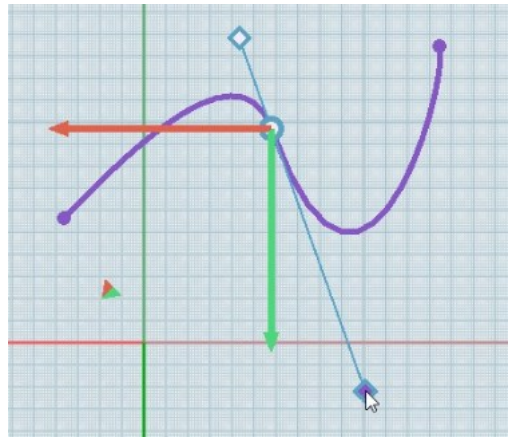


Figure 77 – Asymmetrical controller

- **fractured** (Figure 78). If you pull the marker of one part of the controller, the length and rotation angle of only this part will change, and the second part will remain unchanged. Only the shape of the segment which is controlled by the first part of the controller will change.

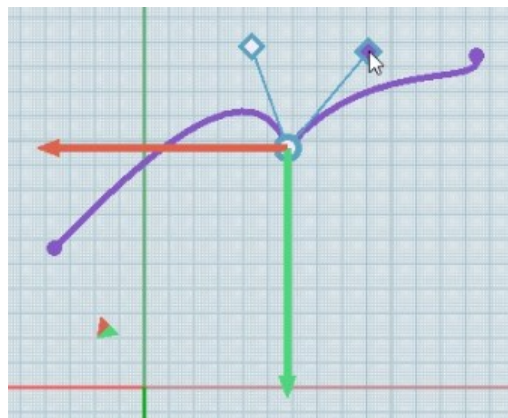


Figure 78 – Fractured controller

The point type and the controller type can be changed using the context menu buttons:

Straightening point , **Symmetrical controller** , **Asymmetrical controller** , **Fractured controller**  (see [2.8 Context menu](#)).

3.6.1.3 GIZMO for a spline point

For the selected point (Figure 79) gizmos are displayed, which consists from:

- two manipulator axes corresponding in color and direction to the active view (for example, if the front view is active, then these are the X and Z axes);
- a manipulator for the free movement in the plane (for example, if the front view is active, then this is a two-color arrow .

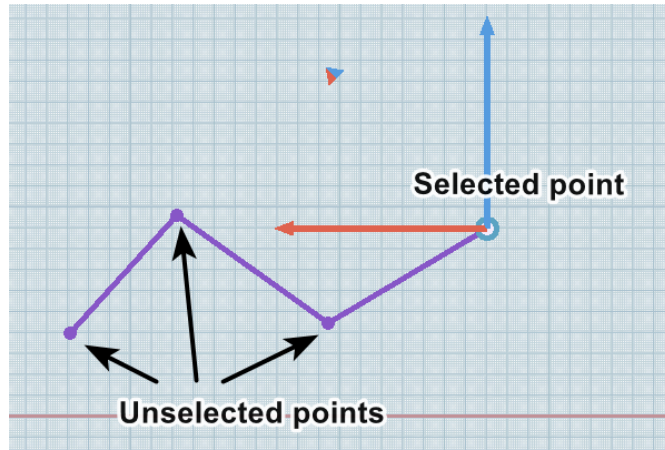


Figure 79 – GIZMO for a selected point

You can move a point in the scene not only by using Gizmo, but also by dragging the point itself.

3.6.2 Creating a spline



You can create a spline only in one of the orthogonal views — in the plane corresponding to this view.

To create a spline:

- 1) Select one of the orthogonal views from the panel in the upper left corner of the work area.
- 2) Turn on the Spline tool by clicking the  button on the control panel.
- 3) Click on the coordinate plane to create a straightening spline control point.



If you want to create a straight spline segment, the next point must also be a straightening point.

- 4) To create a bending control point, click and drag while holding the mouse or finger. The controller for the created bending point will then be displayed. By changing the length and slope of this controller, change the curvature of the lines adjacent to the current control point. When a new control point is created (from the beginning of the pointer movement), a new spline segment is drawn between this point and the previous point. Release the mouse or finger when you get a segment of the desired curvature. By default, the bending point is created with a symmetrical controller (the  button is active).
- 5) Create the next spline points.



Each new point is created selected, so the controller, GIZMO manipulators (Figure 79) and the corresponding set of buttons are displayed for it in the context menu (Figure 80).



Figure 80 – Context menu of a selected spline point

- 6) If necessary, change the point type or its controller type using the buttons in the context menu.
- 7) If necessary, move the created point by using Gizmo (Figure 79) or by dragging the point itself.
- 8) To delete the created point, click the  button in the context menu. The previous point will become selected, and spline creation will continue from there.

- 9) To complete the spline creation, click the  button in the context menu. The creation of the current spline is also completed:
 - at the moment of creating a closed loop. If you click on the first point of the current spline (provided that there are more than two points in the spline), then the creation of the current contour will be completed and the contour will close. The closed contour will be colored inside;
 - when changing the active view to another (for example, horizontal to front);
 - when creating an object from the shape library (the Spline tool is turned off);
 - when you press the Enter key on your keyboard.

The created spline is in editing mode (the edit button in the context menu is active: ).

3.6.3 Spline and point selection

Selecting and deselecting a spline and a point occurs as follows:

- To select a spline, click on it. The spline points will be available for selection, and buttons for working with the spline will appear in the context menu.
- To select a spline point, click on the control point of the selected spline. The context menu will display buttons for working with the point.
- To deselect a point:
 - click on a free area in the scene or on another object. The point is deselected, the spline remains selected. A subsequent click in the free area will deselect the spline. The context menu will display buttons for working with the spline;
 - click on the spline. The point is deselected, the spline remains selected. The context menu will display buttons for working with the spline.

When the spline editing mode is turned on, you can select several points of the spline using a frame or the **Multiple Selection** tool (see [2.4.4 Multiple Selection](#)). One common Gizmo manipulator will be displayed for the selected points. A controller will be displayed for each bending point. The context menu will display buttons for working with points (buttons corresponding to the types of selected points are active in the menu). You can change the type of all selected points, delete them all, round/cut them all. In Figure 81, three spline points are highlighted: two bending ones (with symmetrical (1) and broken (2) controllers) and a straightening one (3), so the buttons are active in the context menu , and .

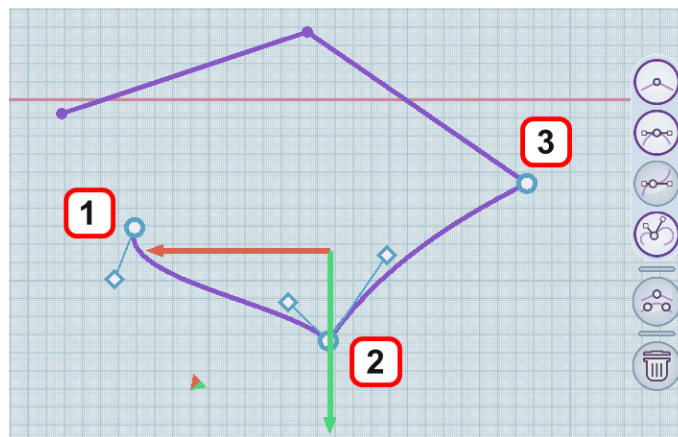


Figure 81 – Three spline points are selected

3.6.4 Editing a spline

To edit a spline, follow these steps:

- 1) Select a spline (see [3.6.3 Spline and point selection](#)).
- 2) If editing mode is turned off (GIZMOs are displayed), turn it on by clicking the  button in the context menu. The Gizmos will disappear and the spline control points will be displayed (Figure 82).



Figure 82 – Selected spline in edit mode

- 3) To edit existing points of a selected spline:
 - select one or more points (by click / frame / **Multiple Selection** tool);

- move the selected points with the pointer behind the point or behind the Gizmo points (Figure 79);
- change the points type or the type of their controllers using the buttons in the context menu (Figure 80).

4) To add a new point to a selected spline:

- Enable the mode of adding new points by pressing the  button in the context menu (Figure 82). A  button appears at the top of the context menu.
- Click on the spline segment where you want to add a new point. Before you release the pointer, you can move the point along the segment. When you release the pointer, the point will be added to the spline (Figure 83).



Figure 83 – Adding a point to a straight spline segment

The type of a new point depends on which segment it is added to:

- if on a straight segment, then the default point type is straightening (the button is active in the context menu  (Figure 83);
- if on a curved segment, then the point type is curved. By default, an asymmetrical controller is enabled for the added point (the button is active in the context menu  (Figure 84).

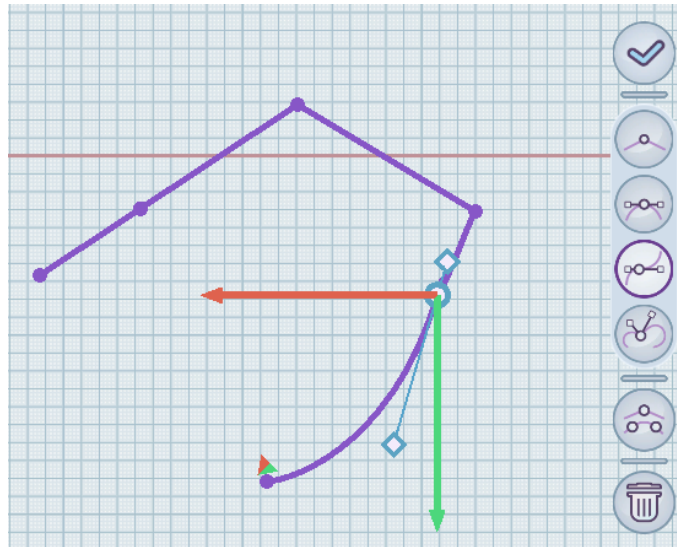


Figure 84 – Adding a point to a curved spline segment

When clicking outside the selected spline area, no point is created.

- c) If necessary, add other new points to the spline.
- d) To exit the mode of adding new points, click the  button.
- 5) To delete a spline point, select it and click the  button in the context menu (Figure 82) or the **Delete** key on your keyboard. When a point is deleted, one segment is built from two adjacent segments of this point, and its shape is recalculated in accordance with the type of points limiting this segment and the type of their controllers.
- 6) To continue the selected spline:
 - a) Press the  button in the context menu (Figure 82). In this case, the last point of the spline will be selected (GIZMO and controller will be displayed for it), and a  button will be displayed at the top of the context menu. The spline will switch to the **Creating a spline** mode (see [3.6.2 Creating a spline](#)).
 - b) Click or tap and then move the pointer in the work area to create a new control point and a new segment for the current spline.
 - c) To exit spline continuation mode, click the  button.
- 7) To round or cut a spline corner, perform a **Rounding/Cutting Off** operation on the point that is the vertex of the corner. For this:
 - a) Select a spline point that is not the first or the last in the spline.
 - b) Press the  button in the context menu. The selected point will switch to the **Rounding/Cutting Off** mode. At the same time, GIZMO and controllers will be hidden at the point. Only the  button is displayed in the context menu.

- c) Click the pointer in the work area and drag it to the left to cutting (Figure 85) or to the right for rounding (Figure 86).



Figure 85 – Cutting

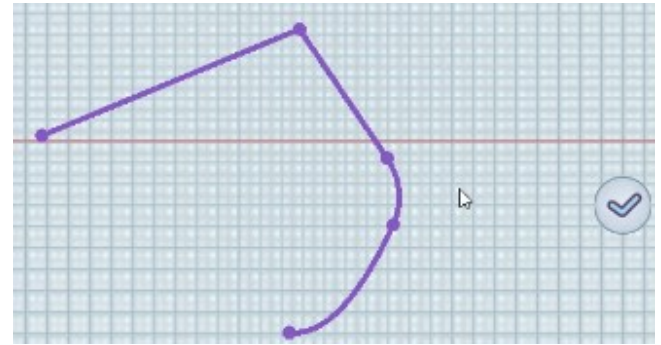


Figure 86 – Rounding

- d) To complete the operation, press the  button. Two new points will be highlighted on the spline (their controllers will be shown and buttons for editing will be displayed in the context menu). To cancel the **Rounding/Cutting Off** operation, click anywhere else on the work area.

If several points are selected and among them there is at least one that is not extreme (not the first and not the last), then the **Rounding/Cutting Off** operation is also available for them — the operation will be applied to all selected points except the first and the last.

3.6.5 Moving and rotating a spline



You can move and rotate a spline only in the plane in which it was created.

The created spline is in the editing mode by default. To move or rotate a spline, turn off the editing mode by clicking the  button in the context menu. GISMO manipulators will be displayed for the spline (Figure 87) (see [2.9 GIZMO manipulators](#)).

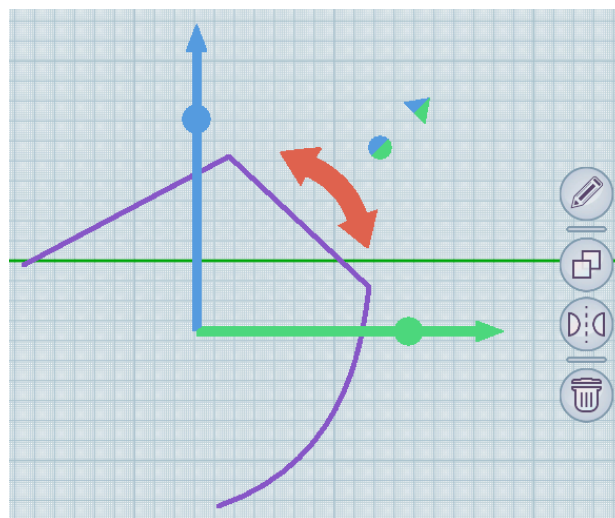


Figure 87 – GIZMO for moving and rotating a spline

3.6.6 Deleting a spline

To delete a spline, select it and click the  button in the context menu.

Spline will also be deleted:

- if a spline of two points is in editing mode and one of its points is deleted. Please note: if you delete one of two points in the spline creation or continuation mode, the spline itself will not be deleted — when you delete all points, the next click will create the first spline point;
- if a spline consisting of only one point and the creation or continuation mode is ended by using the  button in the context menu.

3.6.7 Converting a parametric 2D shape into a spline

To convert a 2D shape into a spline, select the 2D parametric shape on the workspace and click the  button in the context menu. As a result:

- selected 2D shape is converted into a spline. If a figure has vertices, then they all will become control points. A spline formed from a sphere or an ellipsoid will have 4 control points at the intersection of the shape with two perpendicular axes. The appearance of the figure will change to the spline one (Figure 88);

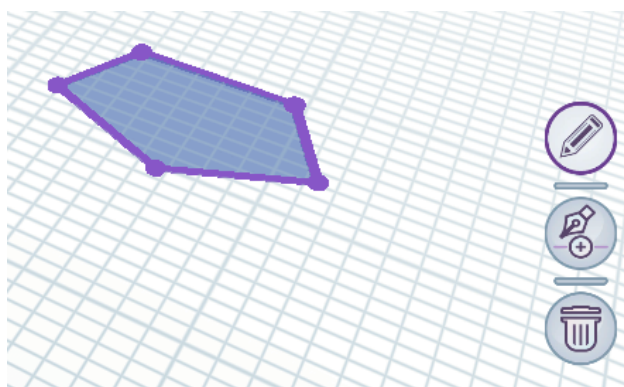


Figure 88 – 2D shape converted into a spline

- the composition of the context menu buttons changes to correspond to a closed spline;
- for a shape converted into a spline, editing mode is enabled by default.

If several 2D shapes are selected, then the  button is also available for them and after the transformation they all will also be selected, but will be in Gizmo mode and the  button will be hidden, since it is not displayed for several selected objects (Figure 89).

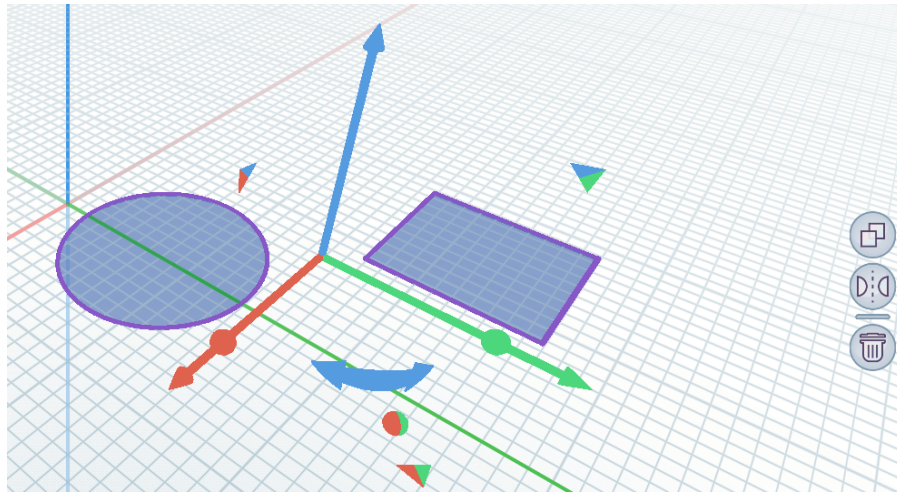


Figure 89 – 2D shapes converted into splines

3.7 Kinematic Operations

A kinematic operation (shaping operation) is the operation of creating a three-dimensional figure by moving a flat figure (sketch) along a trajectory.

The **Kinematic Operations** tool is activated by the **Kinematic Operations** button  on the control panel. A tool settings panel appears above the button, which contains three buttons for selecting a specific operation (Figure 90):

- **Extrusion**  (the button is active by default) (see [3.7.3 Extrusion](#));
- **Rotation**  (see [3.7.4 Rotation](#));
- **Moving Along a Trajectory**  (see [3.7.5 Moving Along a Trajectory](#)).

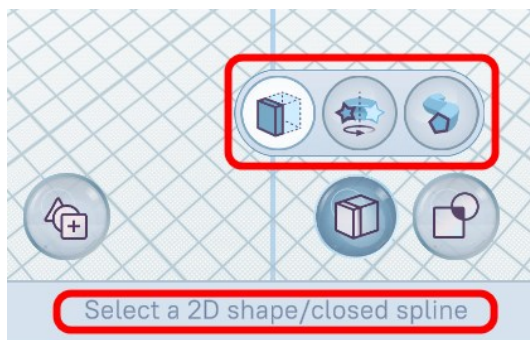


Figure 90 –Tool settings panel and tool tips

While the **Kinematic Operations** tool is enabled (the button is active: ), tips are displayed under the control panel (Figure 90).

3.7.1 Sketch and trajectory creation

2D shapes are used as a sketch (for the **Extrusion**, **Rotation**, **Moving Along a Trajectory** operations) and to specify a trajectory (for the **Moving Along a Trajectory** operation). You can create them from a library of 2D shapes (see [3.1 Creating a shape](#)) or using the **Spline** tool (see [3.6 Spline](#)).

Using a spline, you can create closed or open contours. You can only select a closed contour as a sketch for kinematic operations. In this case, the area bounded by this contour will serve as a sketch for the construction of the final three-dimensional shape.

You can select either a closed or an open contour as a trajectory for the **Moving Along a Trajectory** operation. You can also select a 2D shape, then the closed loop that bounds it will be used as the contour.

3.7.2 Shaping operations

Shaping operations are performed in the following sequence:

- 1) Choose the required shaping operation on the tool settings panel (Figure 90).
- 2) Selection (see [3.2 Selecting \(highlighting\) objects in the scene](#)):
 - select at least one contour or 2D figure as a sketch (for all shaping operations);
 - select one contour as a trajectory (for the **Moving Along a Trajectory** operation).
- 3) Performing the shaping operation:
 - by changing the value of the parameter (parameters) in the input field or by using manipulators (for the **Extrusion** and **Rotation** operations);
 - by completing the operation by pressing the  button (for the **Moving Along a Trajectory** operation).

A shape obtained via the shaping process using **Extrusion** and **Rotation** operations is in the shaping mode.

Shaping mode is a special case of parametric editing mode (see [3.3 Editing a shape](#)).

Parametric editing mode is a mode in which you can edit the parameters of a shape after it was created from the library and until it is converted. The shape mode is a mode in which the shape which was created using the shape operations can be edited using an input field or a manipulator. Shaping mode is also available before the shape is converted.

The applied shaping will be saved for the created volumetric figure. While the created figure is not converted (see [3.7.7 Shape conversion](#)), the parameters of this shaping are available when the created figure is selected (regardless of whether the **Kinematic Operations** tool is active or not), and they can be edited (for example, you can change the extrusion's thickness). The **Convert** button  appears in the context menu.

The figure obtained using the **Moving Along a Trajectory** operation is created in a converted state.

When you apply shaping, the source shapes (2D shapes or contours) that served as sketches to create the solid shape remain as independent entities. From one source shape, you can create several resulting shapes, for example, by rotating and extruding the same source shape. Changes to or deletion of the source shape do not affect the shape created from it.

After the formation begins, the selection is removed from the shapes that served as sketches and trajectories (for the **Moving Along a Trajectory** operation) and the created shape is selected.

3.7.3 Extrusion

The kinematic operation **Extrusion** is the creation of a three-dimensional shape via moving a flat shape (sketch) along a straight line perpendicular to the sketch.

To create a 3D shape using the **Extrusion** tool, follow these steps:

- 1) Create a sketch from the shape library by clicking or extrusion (Figure 91) or using the **Spline** tool.

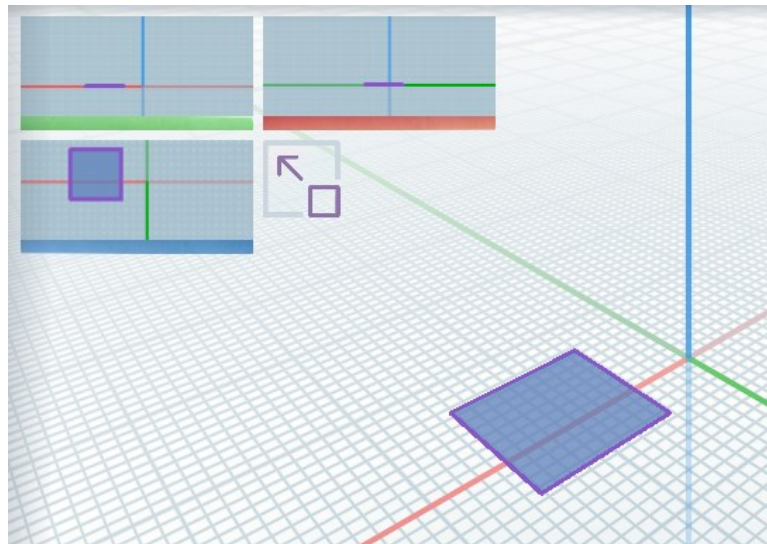


Figure 91 – Creating a sketch by extruding a flat shape from the shape library

- 2) Press the **Kinematic Operations** button  on the control panel (Figure 28). The tool settings panel will appear above the button, and tooltips will be displayed in the properties panel, below the control panel (Figure 90).
- 3) If necessary, activate the **Extrusion** tool by clicking the  button on the tool options bar.
- 4) Select a sketch by clicking on it. There are several options when a sketch is selected (Figure 92):
 - in a perspective view and in two orthogonal views, different from the view in the plane of which the sketch lies, a circle manipulator for extrusion is displayed;
 - the properties panel displays a field for entering the extrusion thickness value.

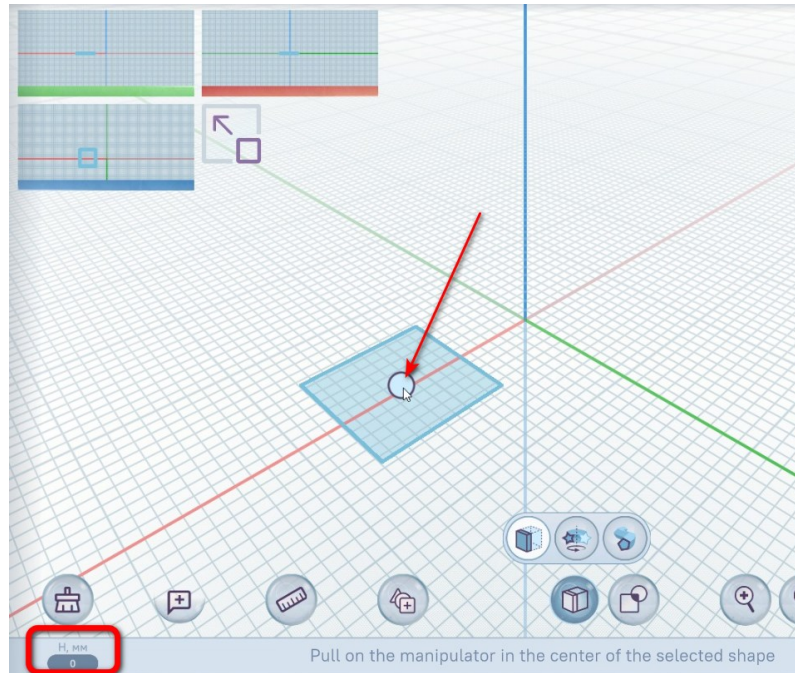


Figure 92 – Extrusion manipulator and field for entering the extrusion thickness value

Create a three-dimensional figure in one of two ways:

- Drag the circle-manipulator along a line perpendicular to the sketch and passing through its pivot. For the sketch in Figure 92, which lies in the XY plane, the circle manipulator will be available for interaction in perspective, frontal (parallel to the XZ plane), and profile (parallel to the YZ plane) views. In Figure 93, a three-dimensional figure is formed by extrusion of the manipulator along the positive direction of the Z axis. In this case, the value of the thickness of the extrusion is displayed in the properties panel.

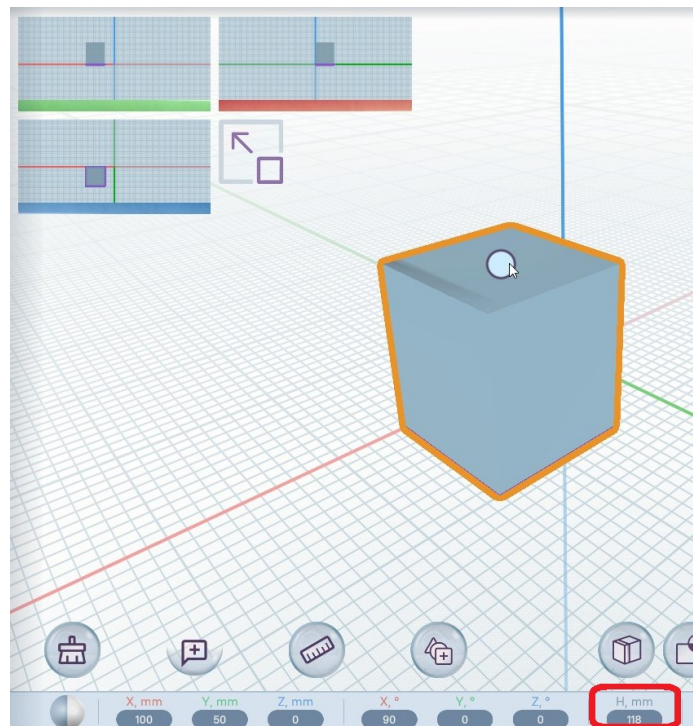


Figure 93 – Extruding a three-dimensional figure using a manipulator

- Enter the extrusion thickness in the input field on the properties panel (allowable change ranges are from 1 to 1000 mm and from –1 to –1000 mm). To do this, click on the input field, enter the value and to confirm the entry, press the Enter key or click outside the input field. A figure will be obtained as a result of extruding the selected sketch to a given thickness and in the direction corresponding to the sign of the entered value: a positive value — extrusion in the direction of the positive direction of the coordinate axis that is perpendicular to the sketch, a negative value — in the opposite direction.

The shape obtained as a result of extrusion is in the shaping mode and is displayed as parametric (see [3.7.7 Shape conversion](#)).

3.7.4 Rotation

The kinematic operation **Rotation** is the creation of a three-dimensional figure by rotating a flat figure (sketch) around an axis.

To create a 3D shape using the **Rotation** tool, follow these steps:

- 1) Create a sketch from the shape library by clicking or extrusion or using the **Spline** tool (Figure 94).

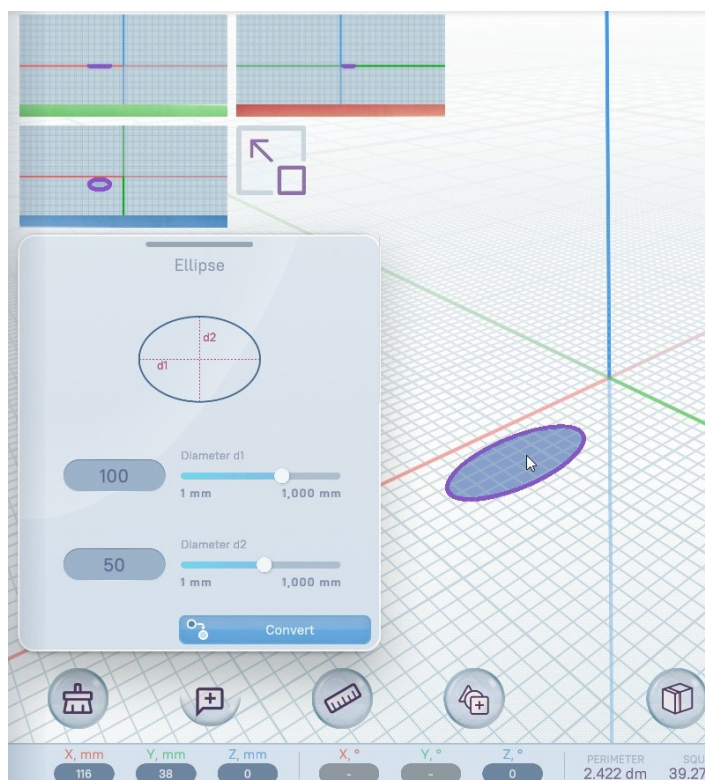


Figure 94 – Creating a sketch by clicking or extrusion

- 2) Press the **Kinematic Operations** button  on the control panel (Figure 28). A panel for selecting a shaping operation will appear above the button, and tips will be displayed in the properties panel under the work area (Figure 90).

- 3) Activate the **Rotation** tool by clicking the  button on the operation selection panel.
- 4) Select a sketch by clicking on it. When a sketch is selected (Figure 95):
 - a circle-manipulator is displayed in the sketch pivot;
 - an infinite rotation axis is displayed in the plane of the selected sketch, which by default passes through the sketch pivot;
 - the properties panel displays a field for entering the value of the radius of rotation (displacement of the axis of rotation relative to the sketch pivot) in millimeters and a field for entering the value of the angle of rotation in degrees.

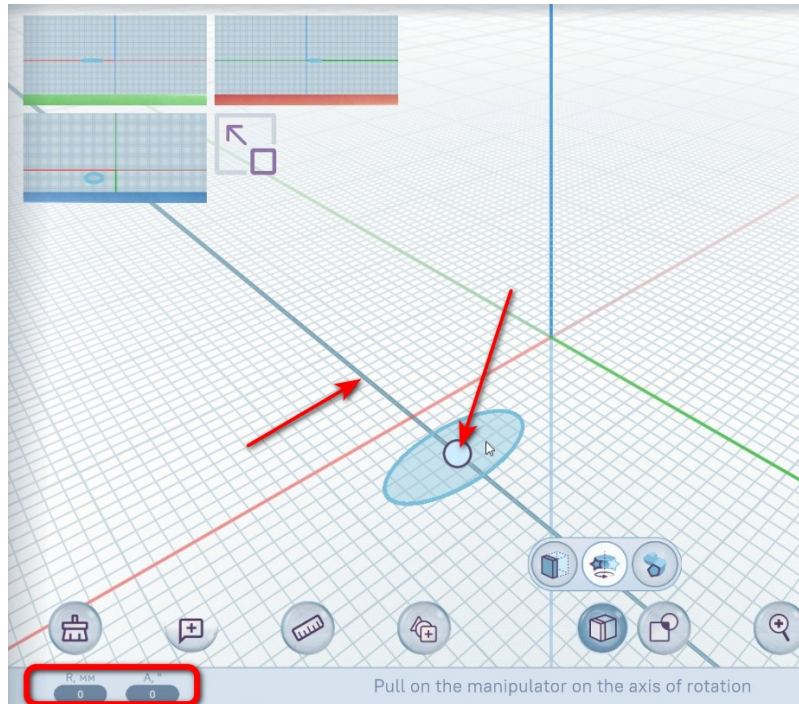


Figure 95 –Rotation axis, rotation manipulator, and input fields



*If you deselect the sketch or switch to another operation (**Extrusion** or **Moving Along a Trajectory**), the rotation axis will disappear from the work area.*

- 5) If necessary, set the radius of rotation of the sketch. To do this, shift the axis of rotation by the radius in one of two ways:
 - pull the manipulator circle, moving the axis in the sketch plane (in Figure 96 — in the XY plane);
 - change the axis position using the axis offset value input field on the properties panel (valid values are from 0 to ± 5000). To do this, click on the input field (Figure 96), enter a value and to confirm the entry, press the Enter key or click outside the input field.

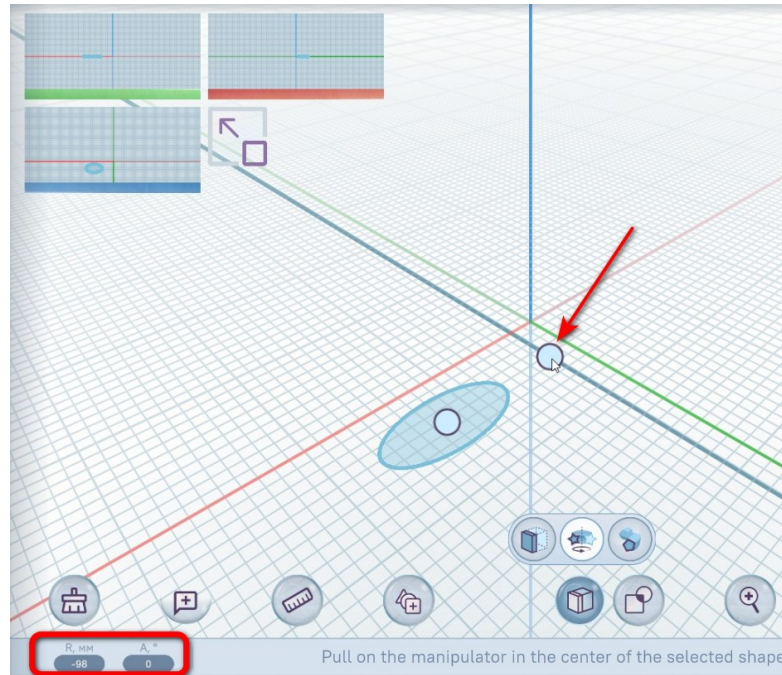


Figure 96 –XY axis offset

- 6) Create a three-dimensional shape in one of two ways:
- pull the circle manipulator on the sketch (Figure 97);

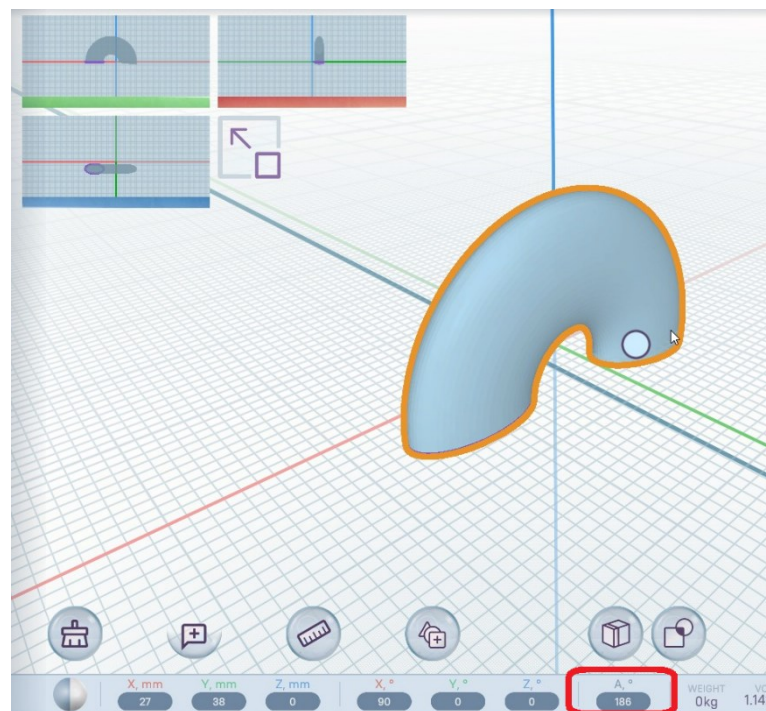


Figure 97 –Creating a 3D shape using the rotation manipulator

- enter the value of the rotation angle in degrees in the input field on the properties panel (valid ranges are from 0 to $\pm 360^\circ$). To do this, click on the input field, enter the value and to confirm the entry, press the **Enter** key or click outside the input field. A figure will be obtained as a result of rotating the sketch at a given angle and in a given direction.

Once shaping begins, the rotation axis is displayed, but cannot be moved.

The resulting shape is in the shaping mode and is displayed as parametric (see [3.7.7 Shape conversion](#)).

3.7.5 Moving Along a Trajectory

The kinematic operation **Moving Along a Trajectory** is the creation of a three-dimensional shape by moving a flat figure (sketch) along an arbitrary trajectory. This operation requires the selection of two objects: one as a sketch, the other as a trajectory.

To create a 3D shape using the **Moving Along a Trajectory** tool, follow these steps:

- 1) Create a sketch by clicking or dragging from the shape library or using the **Spline** tool.
- 2) Create a sketch's trajectory by clicking or dragging from the shape library or using the **Spline** tool.
- 3) Press the **Kinematic Operations** button  on the control panel. The tool settings panel will appear above the button, and tooltips will be displayed in the properties panel, below the control panel (Figure 90).
- 4) Enable the **Moving Along a Trajectory** tool by clicking the  button on the tool settings panel. An additional panel will appear with buttons for selecting a path and a sketch (Figure 98).

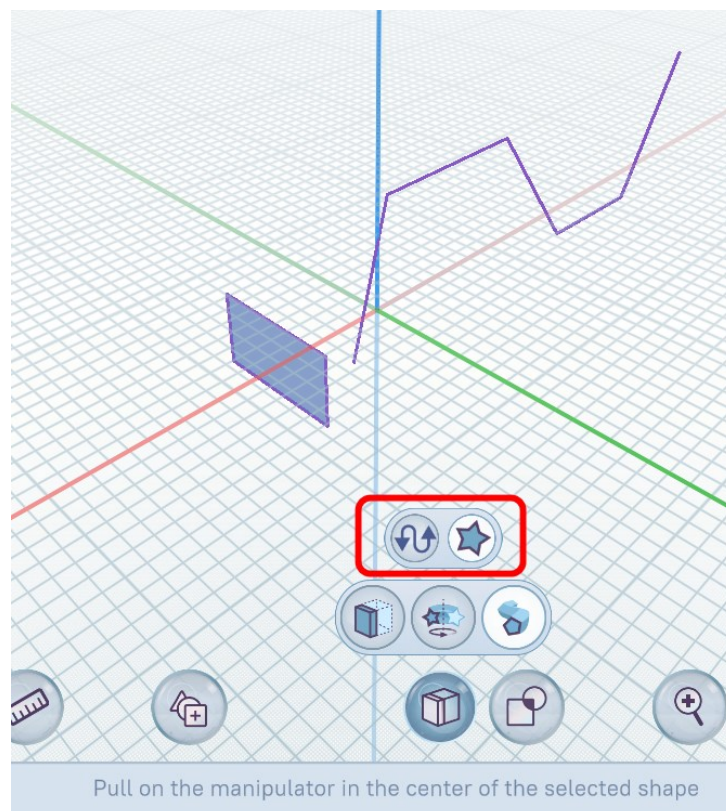


Figure 98 – Trajectory and sketch selection panel

- 5) If the sketch selection button is inactive , click it and select a 2D shape or a closed contour as a sketch (click on it).

- 6) Click the  button and select a closed or open contour or a 2D shape as the trajectory. After selecting both a sketch and a trajectory, a **Use** button  will appear next to the settings selection panel.
- 7) To complete the **Moving Along a Trajectory** operation, click the  button.

The shape obtained by moving the selected sketch along a given trajectory is displayed in the scene in all views. This shape is immediately converted (Figure 99).

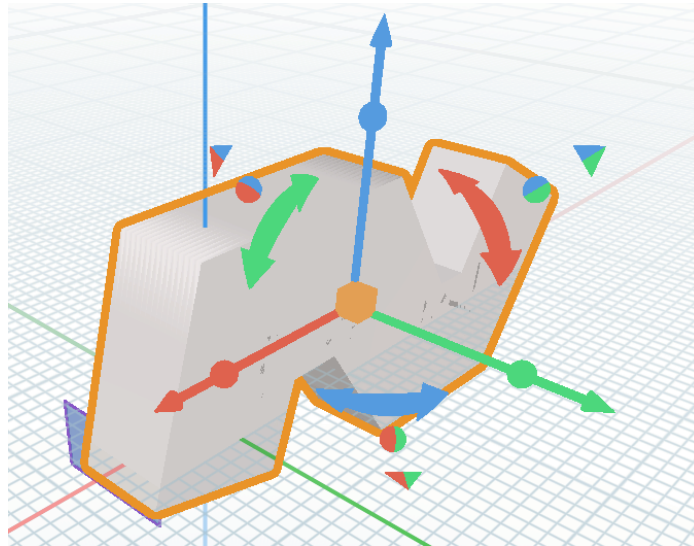


Figure 99 – Result of the Moving Along a Trajectory operation

3.7.6 Kinematic operations for nested figures

As a sketch for any kinematic operation, you can select several 2D shapes lying in the same plane. If one 2D shape is selected, after that only 2D shapes in the same plane are available for selection. In case of a multiple selection, when 2D shapes lie in different parallel planes, the shape that was chosen first is selected.

The kinematic operation is performed on all selected 2D shapes, taking into account their intersections and nestings as follows. The areas between the contours of the shapes alternate their roles one after the other, starting from the outermost one. First, the sketch area is the area between the outermost outline and the next one nested within it, the next nested area is taken as a hole, the next nested shape is again taken as a sketch, etc. For example, if you select 4 nested circles as a sketch, as in Figure 100, the extrusion operation will result in 2 areas being used as the sketch for the final shape, and 2 areas used to create the holes (Figure 101).

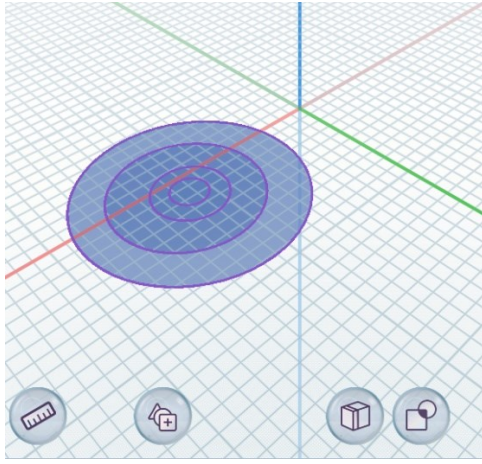


Figure 100 – 4 nested circles

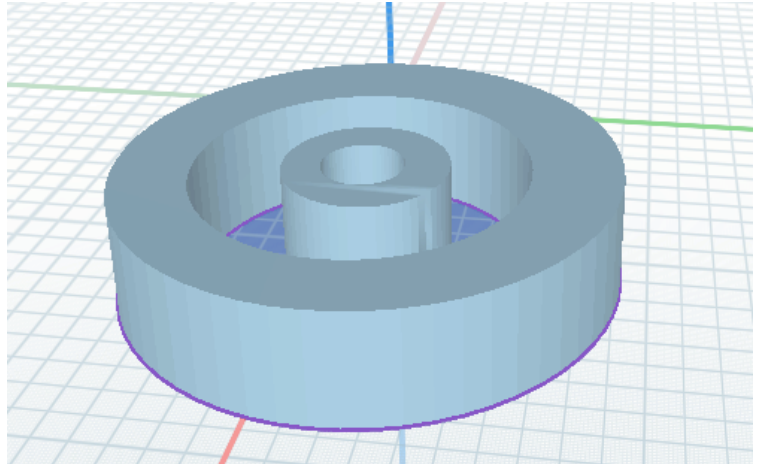


Figure 101 – Result of the Extrusion operation

3.7.7 Shape conversion

A shape created using an extrusion or rotation operation is in non-converted mode (similar to parametric shapes) (Figure 102). Until the shape is converted, the manipulator and input field corresponding to the shaping operation with which it was created will be displayed in the editing mode, regardless of the activity of the Kinematic Operation tool and the currently active shaping operation. Until the shape is converted, scaling manipulators are not available for it.

The converted figure is displayed in the scene in a light gray color (Figure 103). For a shape converted after shaping, no further editing by shaping is possible, but all the manipulators, tools and properties that are available for a converted shape created from a shape library are now available.

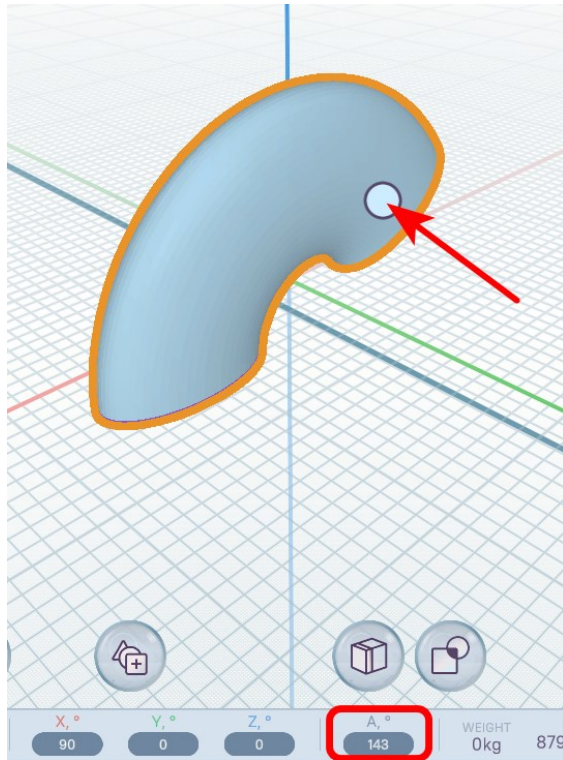


Figure 102 – Unconverted figure

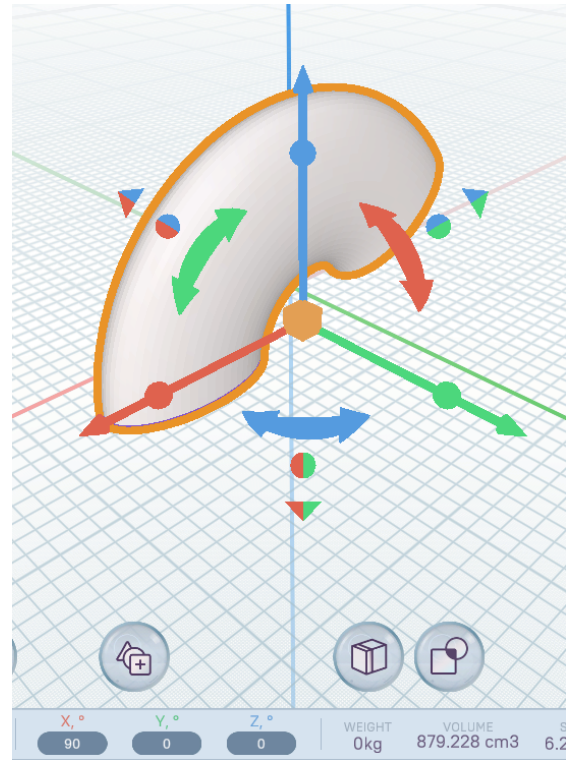


Figure 103 – Converted figure

3.8 Boolean Operations

A boolean operation is a union, intersection, or subtraction operation on multiple shapes (operands) that results in one final shape.

The **Boolean Operations** tool is activated by the **Boolean Operations** button  on the control panel. A tool settings panel appears above the button (Figure 104), which contains three buttons for selecting a specific operation:

- **Union**  (active by default) (see [3.8.1 Union and intersection](#));
- **Intersection**  (see [3.8.1 Union and intersection](#));
- **Subtraction**  (see [3.8.2 Subtraction](#)).

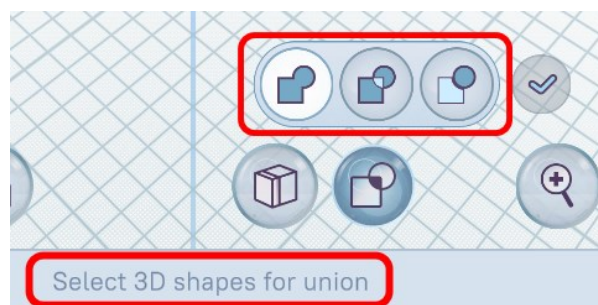


Figure 104 – Tool settings panel and tooltips

To the right of the settings panel is a button  for applying a boolean operation to selected objects.

While the **Boolean Operations** tool is enabled (the button is active: ) , tooltips are displayed below the control panel (Figure 104).

To select objects as operands for the selected operation, you should perform the same steps as for normal selection (see [3.2 Selecting \(highlighting\) objects in the scene](#)). The figure resulting from a boolean operation will be converted and in scale mode, regardless of whether its operands were in parametric mode or not.

3.8.1 Union and intersection

To create a shape using the Union or Intersect tool, follow these steps:

- 1) Press the **Boolean Operations**  button on the control panel (Figure 28). A tool settings panel will appear above the button, and tooltips will be displayed in the properties panel, below the control panel (Figure 104).
- 2) If necessary activate the **Union** tool ( button) or the **Intersection** tool ( button) on the tool settings panel.
- 3) Select 3D shapes as operands for the selected operation and click the  button.

As a result of **combining** several shapes, you will get one shape that contains all the points of the original operand shapes, with the exception of duplicates of the common points (Figure 105).

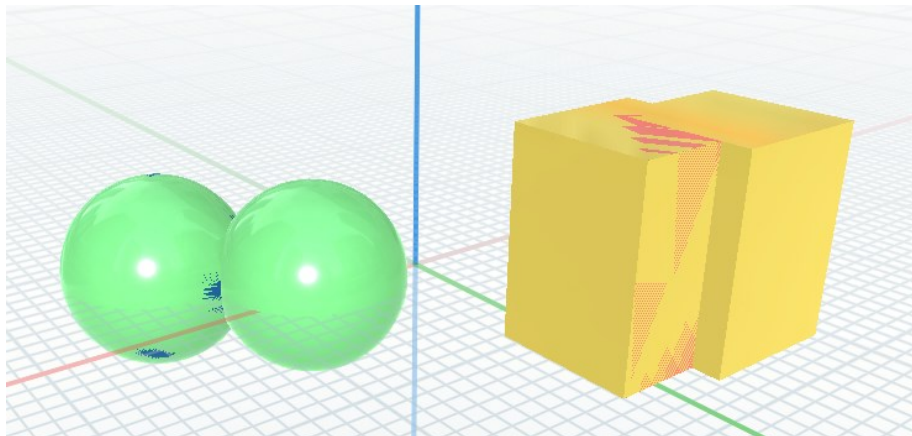


Figure 105 – An example of combining spheres and parallelepipeds

The figure obtained as a result of the **intersection** operation contains only those points that are common to all original operand figures (Figure 106). If the shapes do not contain common points, emptiness will emerge as a result.

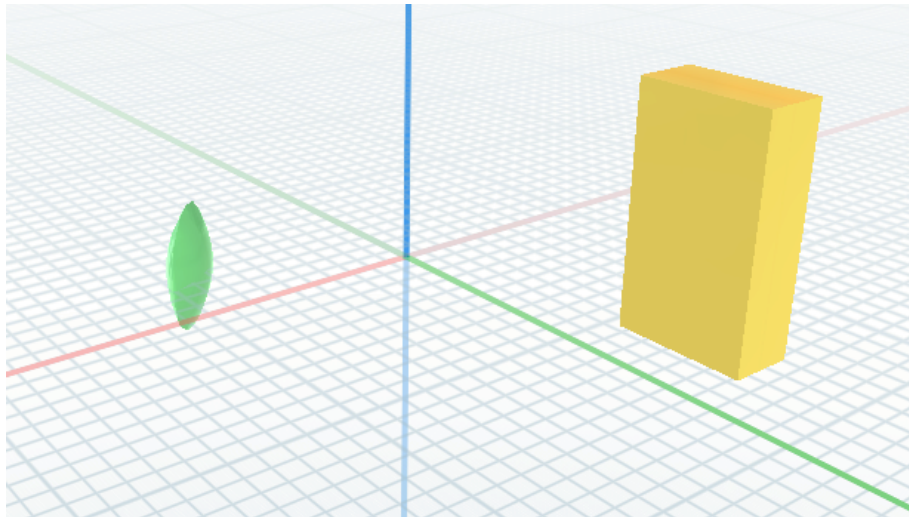


Figure 106 – An example of the intersection of spheres and parallelepipeds

The material of the resulting shape will be the same as the material of the first shape allocated as the operand of the boolean operation.

3.8.2 Subtraction

To create a 3-D shape using the **Subtraction** tool, follow these steps:

- 1) Press the **Boolean Operations**  button on the control panel (Figure 28). A tool settings panel will appear above the button, and tooltips will be displayed in the properties panel, below the control panel (Figure 104).
- 2) Activate the **Subtraction** tool by clicking the  button in the tool options bar. An additional panel appears that allows you to set whether clicking the pointer selects the shape as a minuend or as a subtract (Figure 107).

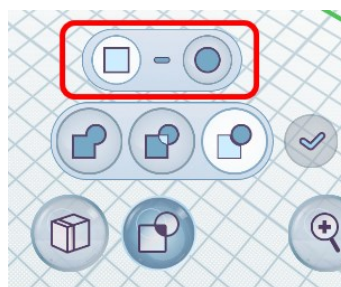


Figure 107 – Minuend and Subtract selection panel

- 3) If the minuend selection button is inactive , click it and select the shape as the minuend.
- 4) Click the  button and select one or more shapes as subtracts.
- 5) Finish the operation by pressing the  button.

The shape that results from subtraction contains only the points of the minuend figure, with the exception of those points that are common to the minuend and subtract (Figure 108). If the figures do not contain common points, the result will be a minuend figure, and the subtract figures will disappear.

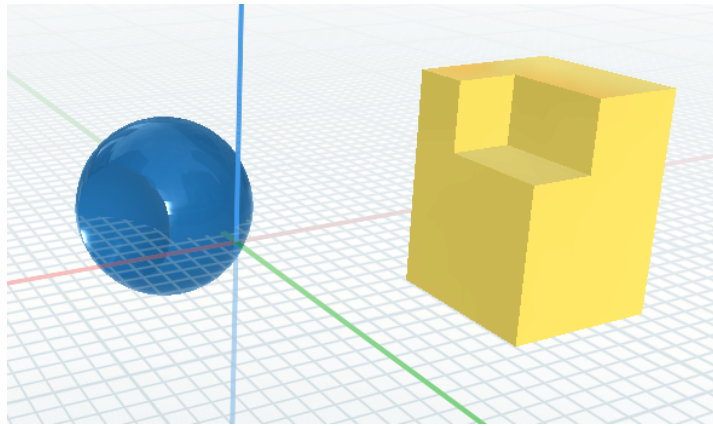


Figure 108 – Example of subtracting spheres and parallelepipeds

The material of the final shape will be the same as the material of the shape selected as the one to be reduced. If the material being reduced is not specified, then it will also not be specified for the final shape.

3.9 Copy

The **Copy** tool allows you to create a new shape identical to the original one. To create a copy, select the original shape and click the **Copy** button  in the appearing context menu.

3.9.1 Copying a 3D shape

Copying a 3D shape creates a copy of the selected shape (or shapes), oriented in the scene in the same way as the original shape, but shifted relative to the original along three axes. Coordinates of the copy shape are $(X+10; Y+10; Z+10)$, where X, Y, Z are the coordinates of the original shape.

If a material and color are specified for the original shape, then these properties are also copied for the created shape.

If you copy a shape that is in parametric editing mode, the created copy shape will also have the parametric editing state, and if you copy a converted shape, the copy shape will also be converted. Accordingly, after creation, parametric manipulators will be active for a parametric copy shape, and rotation/movement/scaling manipulators will be active for the converted one.

The copy shape is created selected, and the original shape is deselected.

3.9.2 Copying a 2D shape

As a result of copying a 2D shape, a copy of the selected shape is created in the same plane as the original with an offset along two coordinate axes lying in this plane (for example, when copying a shape lying in the XY plane, the X and Y coordinates of the shape are copies will be offset by "+10" (Figure 109).

The copy shape is created selected, and the original shape is deselected.

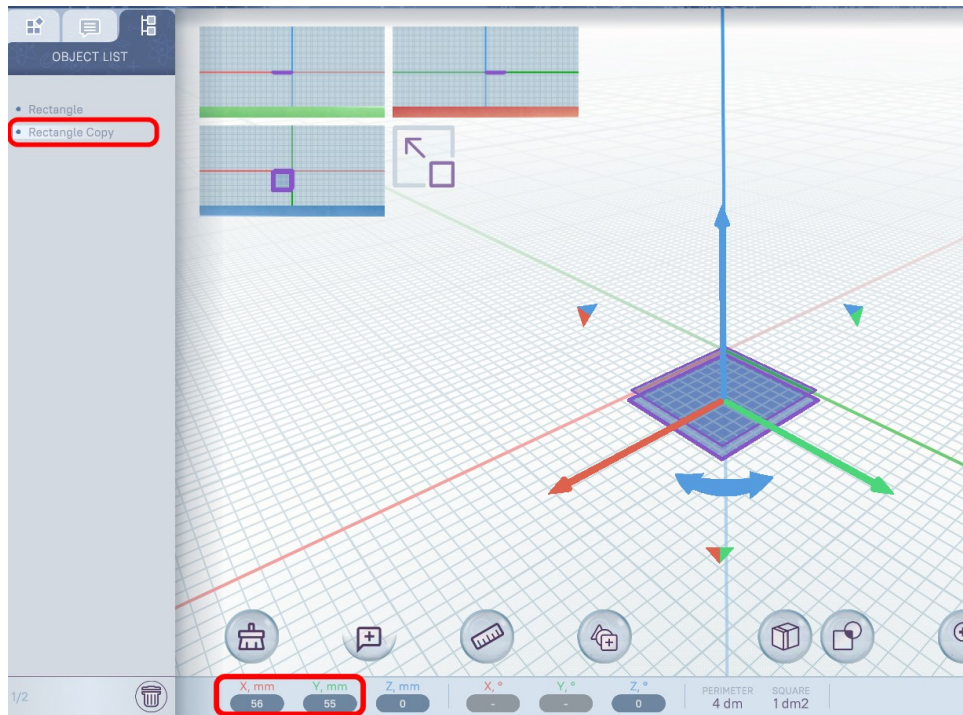


Figure 109 –Copying a 2D shape

3.10 Reflection

The **Reflection** tool allows you to create a new shape that is a reflection of the original shape relative to the selected plane/axis. To create a reflection shape, select the original shape and click the **Reflection** button  in the appearing context menu.

3.10.1 Reflection a 3D shape

If a 3D shape is selected, then after clicking the  button to the left of it, a panel for selecting the plane relative to which you want to reflect the shape will be shown (Figure 110).

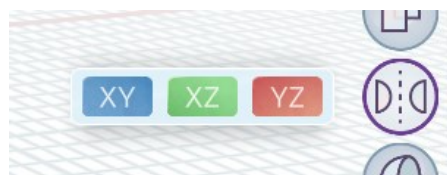


Figure 110 – Plane selection panel

A new shape will be created, which is a converted mirror image of the original shape relative to a plane parallel to the one selected in the panel (Figure 110) and passing through the center of the shape. The reflection shape is created selected, and the original shape is deselected (Figure 111).

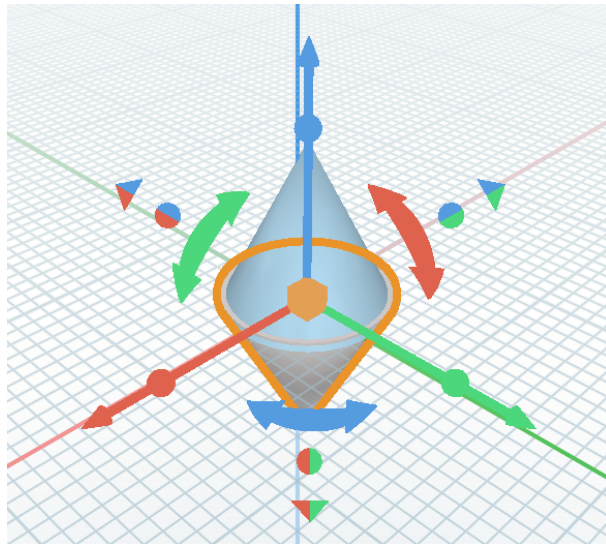


Figure 111 – Reflection a 3D shape relative to the XY Plane

3.10.2 Reflection a 2D shape

If a 2D shape is selected, then after clicking the  button to the left of it, a panel for selecting the axis relative to which you want to reflect the shape will be shown (Figure 112). The axis selection panel contains two buttons corresponding to the axes lying in the plane of the original shape (for example, for the XY plane — the **X** and **Y** buttons).



Figure 112 – Axes selection panel

A new 2D shape will be created, which is a mirror image of the original shape converted to a spline along an axis parallel to the one selected in the panel (Figure 112) and passing through the center of the shape. The reflection contour is created selected, and the original shape is deselected (Figure 113).

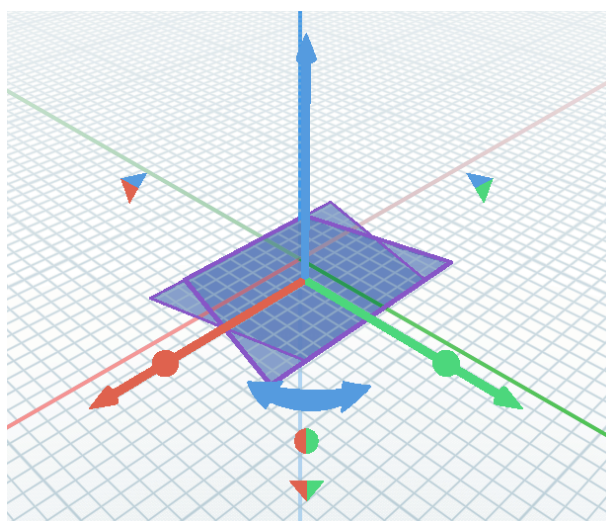


Figure 113 – Reflection a 2D shape relative to the X axis

3.11 Shell

The **Shell** tool allows you to transform a 3D shape in such a way that only its surface remains with a wall thickness of 1 mm so a hollow shape is created. To do this, select the original shape in the context menu and click the **Shell** button . The button is available for all 3D shapes (parametric and converted) that are not shells.

The appearance of a shape converted to a shell does not change. You can see the external difference only by performing a boolean operation (Figure 114).

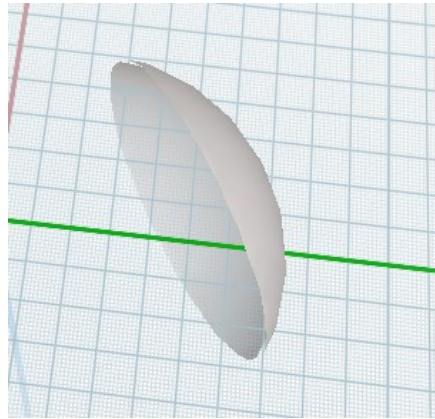


Figure 114 – Shell

For a shell figure, the mass and volume are calculated and displayed in the properties, taking into account the thickness of the shell. The inscription **Shell** is displayed in the properties panel (Figure 115).

WEIGHT	VOLUME	SQUARE	SHELL
0.604kg	31.297 cm3	6.359 dm2	

Figure 115 – Shell's properties

4 Camera control

You can control the camera using the following tools:

- input devices (mouse, touch screen, touchpad) (see [4.1 Input devices](#));
- **Cube** manipulator (see [4.2 Cube manipulator](#));
- camera control buttons on the control panel (see [4.3 Camera control buttons](#));
- **Default Camera** button  (see [4.4 Default Camera button](#)).

4.1 Input devices

To control the camera with the mouse use:

- camera rotation — move the mouse while holding down the left button (with the **Multiple Selection** tool disabled);
- moving (panning) — move the mouse while pressing the wheel;
- zooming — scroll the mouse wheel.

To control the camera using the touch screen (with your fingers):

- rotation — press one finger on the screen and drag;
- moving — press two fingers on the screen and drag;
- zooming — pinch/spread two fingers across the screen.

To control the camera using the touchpad:

- rotation — press the left touchpad button and drag;
- moving — while holding down the **Ctrl** key, press with two fingers and drag;
- zooming — scroll the wheel or pinch/spread two fingers on the touchpad.



By controlling the camera with two fingers, you can simultaneously zoom and move the camera.



In orthogonal view mode, only zooming and moving are available; camera rotation is not available. At the same time, the gestures that are used to rotate the camera in perspective view mode here become additional gestures for moving it.

4.2 Cube manipulator

The **Cube** manipulator (Figure 116) is displayed only in perspective view mode and is used to rotate the camera and quickly move to a specific camera rotation (view).

The cube is oriented in space in the same way as the X, Y, Z axes of the scene. In this case, the edges of the cube are pairwise parallel to the coordinate planes and have the same color designation as the planes:

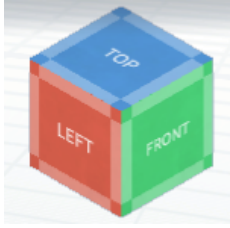


Figure 116 – Cube manipulator

- the **Top** and **Bottom** edges are parallel to the XY plane, color blue;
- the **Back** and **Front** edges are parallel to the XZ plane, green;
- the **Left** and **Right** edges are parallel to the YZ plane, the color is red.

Rotate the manipulator — the camera will rotate in accordance with the direction and angles of rotation of the cube.

Click on the edge of the cube — the camera will rotate so that the plane corresponding to the pressed edge becomes parallel to the screen (for example, click on the **Left** edge to get a left view of the scene). Click on the vertex or edge of the cube — the cube will turn towards the screen with this vertex or edge, respectively (i.e. this vertex or edge will be closer than the other vertices/edges to the screen plane) and the camera will rotate with it.

4.3 Camera control buttons

There are buttons on the control panel to control the camera (Figure 117):



Figure 117 – Camera control buttons

-  — to zoom in;
-  — to zoom off;
-  — focus on the selected object. The button is active when at least one object is selected in the scene. After pressing the button, the camera will move so that the selected object is in the center of the screen;
-  — show the scene.

To return to the default view, click the  button.

4.4 Default Camera button

When you press the **Default Camera** button , the camera returns to its default position, in which it is rotated so that the Z axis is up, the X axis is diagonally down and left, and the Y axis is diagonally down and right.