

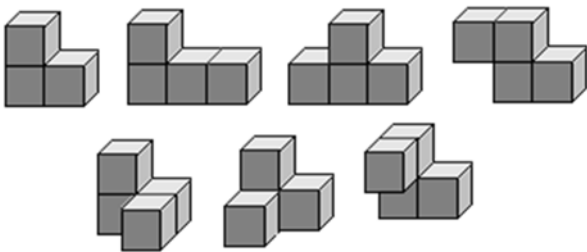


## WORKSHEET 1



### TinkerCAD – Soma Cube

Soma Cube is a logic puzzle composed of seven different 3D shapes that can be assembled into a cube or other objects. It develops spatial imagination, logical thinking and creativity. It is used in mathematics education, design and as a relaxing puzzle.



Source:

<https://home.adelphi.edu/~stemkoski/mathematrix/somacube.html>

#### 1 – First Cube

We can see the different parts of the soma cube in the picture above and use them as a template for our creation. As you can see from the picture, the procedure will be quite simple and we will start with single cube.

**STEP 1:** From "Basic Shapes" insert a "Box" and set its size according to how big you want the soma cube parts to be. In our case we chose 10x10x10 mm.

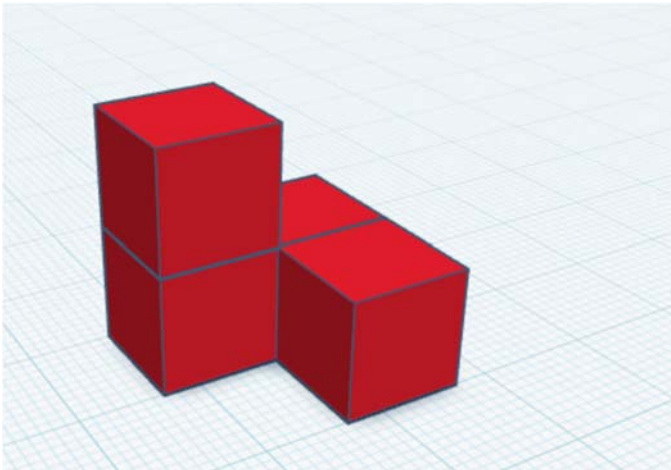
**STEP 2:** Use the "Duplicate and Repeat" tool (CTRL + D) in the upper left corner of the screen to create a copy of the cube. The copy will be placed in the same position as the original cube.

**STEP 3:** Move the new cube to position it as needed - see the soma cube pattern.

**STEP 4:** Repeat the same process until you get the first shape consisting of three or four cubes.

**TIP:** Instead of "Duplicate" we can use the classic way with the clipboard (CTRL + C, CTRL + V). However, the disadvantage of this is that the cube will be placed in a different place when inserted and subsequent movement will be more complicated for us.



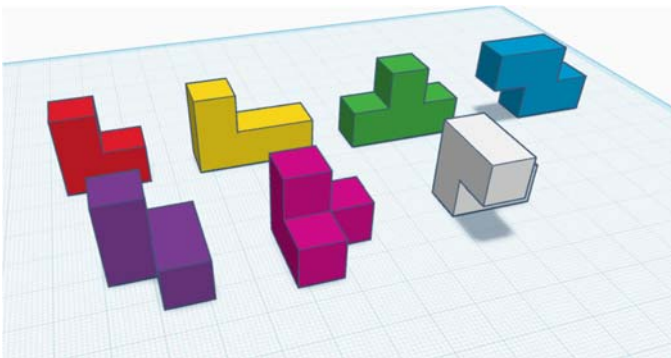


**STEP 5:** Select all cubes and "Group" (CTRL + G).

## 2 – Remaining cubes

**STEP 6:** Create the other cubes in the same way as the first cube.

**STEP 7:** We can set a separate color for each cube, but this is not relevant for 3D printing itself.



**TIP:** It is advisable to rotate the individual cubes in advance (or in the slicer before printing) so that no supports are needed.



## WORKSHEET 2



### TinkerCAD – Story cubes

Story Cubes are picture cubes used to encourage creativity and storytelling. Players roll the cubes and create a story based on the symbols shown. They are used in education, in the development of imagination, language skills and improvisation. Using 3D printing, we can make our own dice according to our needs and interests.



#### 1 – Basic shape "Box"

**STEP 1:** Select the "Box" object in "Basic Shapes". If we don't see it, we can also use the magnifying glass icon and try to find the object.

**STEP 2:** We can set the size of the box according to our needs, we used 20x20x20 mm.

#### 2 – Inserting symbols

In Tinkercad's shape library, you can find various shapes. However, this menu is limited and many of the shapes are unnecessarily complicated for our purpose of simple symbols on a cube. So we will use the vector image import options in Tinkercad.

There are many repositories of objects, models, icons and images on the web. One of them is <https://www.svgrepo.com/>. The

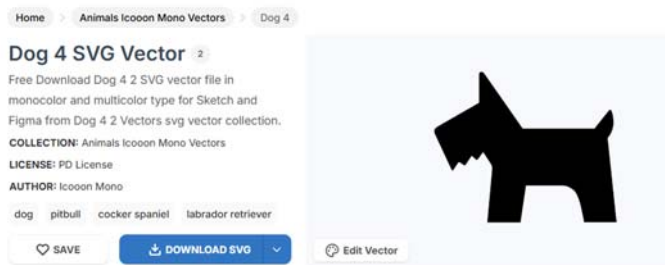
images here should be under a public domain license, so we can use them to create our cube.

SVG is a format for vector images that we can import into TinkerCAD and then make 3D objects from them.

**STEP 3: Open (in a new window)**  
<https://www.svgrepo.com/>.

**STEP 4:** To the search bar on the <https://www.svgrepo.com/> write what you are looking for picture (write in English). Let's try "dog" (ENTER) first.

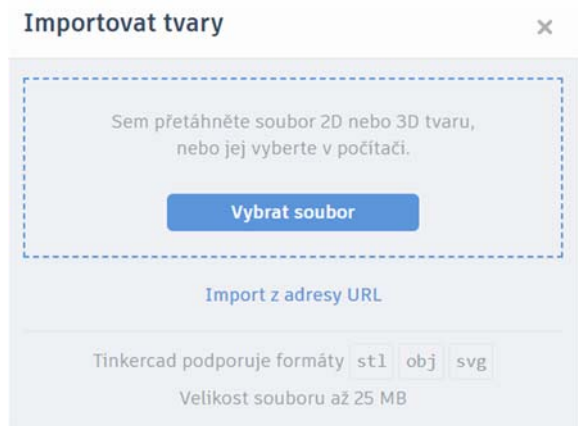
**STEP 5:** After searching the results, choose the image you like and click on the "DOWNLOAD SVG" button to download and save the image to your computer.



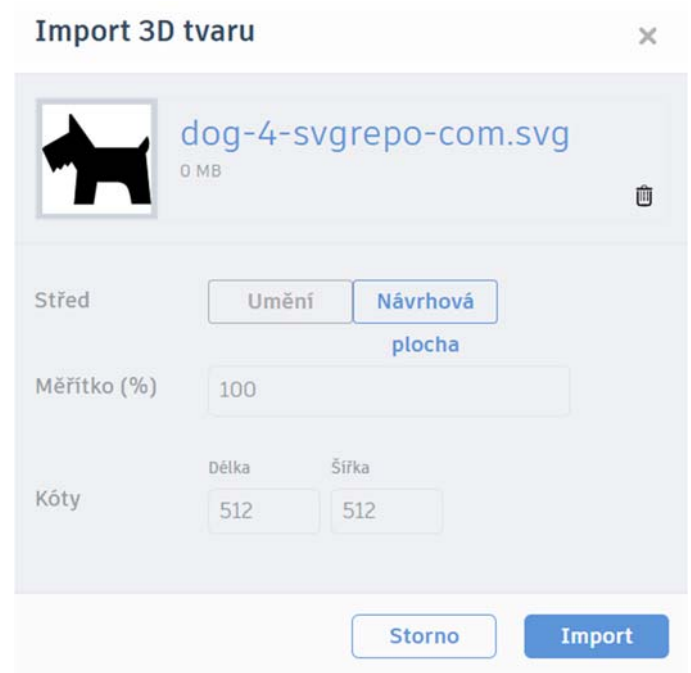
**STEP 6:** In Tinkercad, click on the "Import" button in the top right.

**STEP 7:** Next, choose "Select File" and you'll find our saved dog image file on disk.

**TIP:** TinkerCAD allows us to import 2D svg images but also 3D models in stl and obj formats so we can directly import a 3D model obtained from, for example, the Thingiverse database..



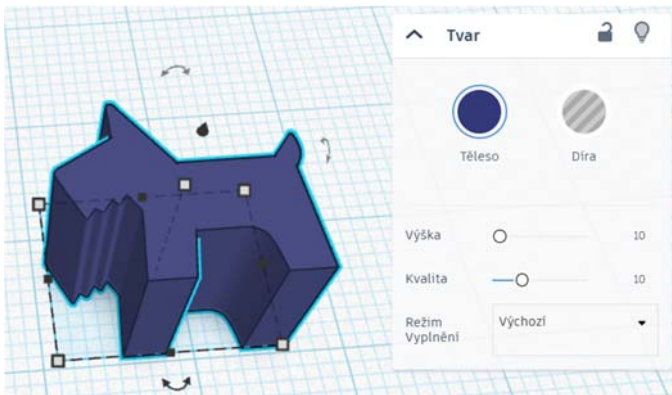
**STEP 8:** In the following dialog, it is advisable to check and adjust the size if necessary. Since our dog is 512x512 and the cube is 20x20, shrinking is advisable.



**TIP: CAUTION!** It may happen that some image or model cannot be imported, the reason may be the size of the image or wrong svg file format. In this case it is easiest to find another image in the large database.

### 3 – Shape on a cube

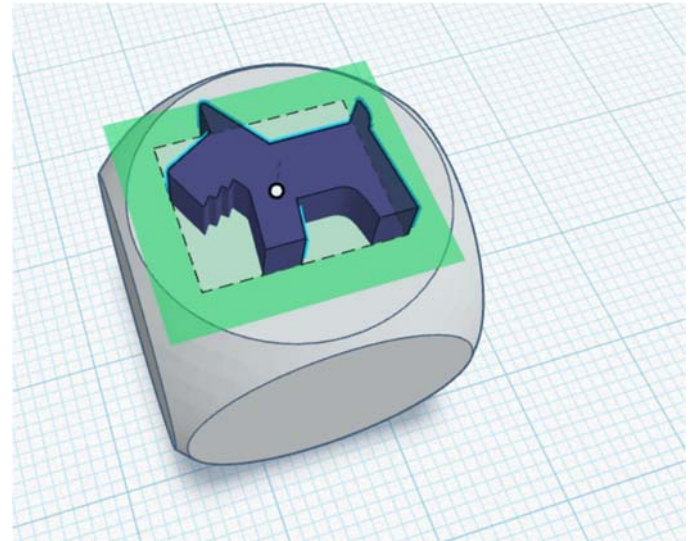
**STEP 9:** After Import, the image will be displayed on the "Workplane" as a 3D shape along with the "Shape" dialog. Using it or directly in the dimensions, we can further adjust the size of the shape and the so-called "fill mode". Set the size so that the shape fits on one of the sides of the cube approx. 12x10x3 mm.



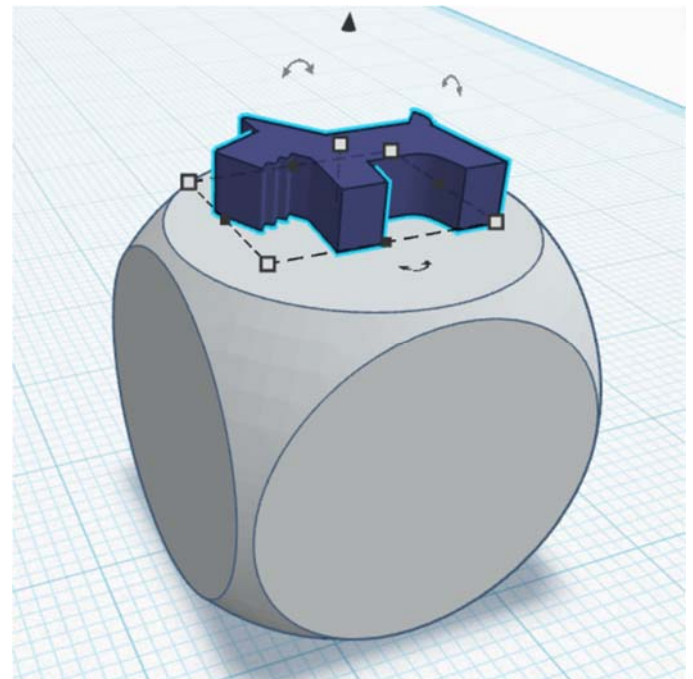
**STEP 10:** To make it easier to place the shape on the side of the cube, select the shape and use the "Cruise" tool (C) in the upper left corner - the magnet icon.

**STEP 11:** Once the "Cruise" tool is activated, we can grab the shape by the white round point and move it to one of the sides of the

cube - it will snap to it.

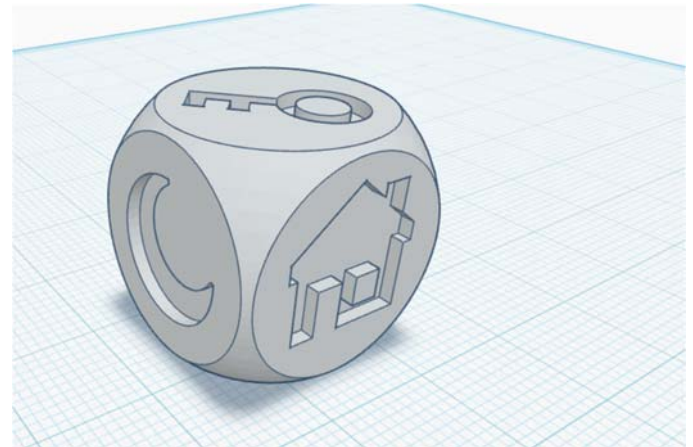
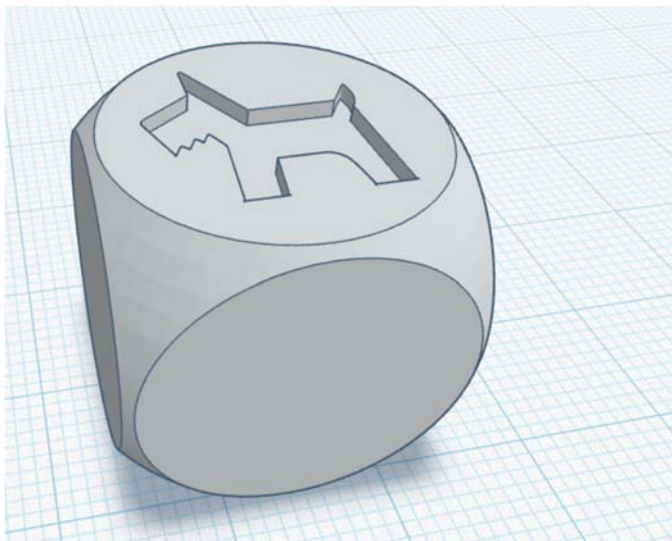
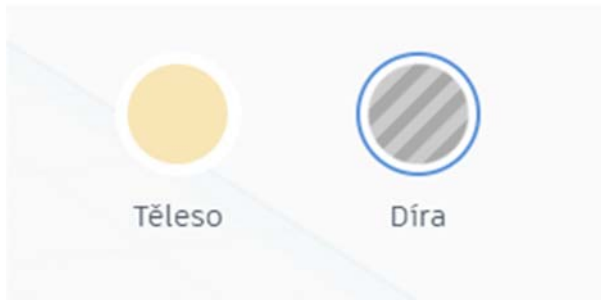


**STEP 12:** Move the shape behind the black arrow and insert it into the cube by approx. 1-2mm.



**TIP:** The level of embedding depends on the size of the cube and for more precise movement we can set a finer "Step" in the lower left part of the Workspace. On our cube we embedded the shape by 1.25 mm.

**STEP 13:** Switch the shape from Body to "Hole" and Group the objects (CTRL + G).



**TIP:** We can certainly make more dice with different shapes to make our game more varied.

**TIP:** When printing, it is advisable to choose which side of the dice will be placed on the mat - choose a simple shape so that there are as few bridges as possible for printing (using supports is possible, but usually not necessary).

### 3 – Creating a shape on a cube

**STEP 14:** From Step 3 we can repeat the process for all sides of the cube.

**TIP:** For simplicity, it is better to download all required shapes from <https://www.svgrepo.com/> and then just insert and edit them in Tinkercad.

**TIP:** Instead of the "Box" shape, we can model another shape in Tinkercad, e.g. a multi-wall cube.



## WORKSHEET 3



# TinkerCAD - Creating a keyring with a name

The name tag keyring is a simple creation where we will demonstrate the basic principles of modelling using a "body" and a "hole" to create a composite object from multiple shapes. The basic design can also be further modified in any way (e.g. different dimensions of individual elements).

## 1 – Basic shape

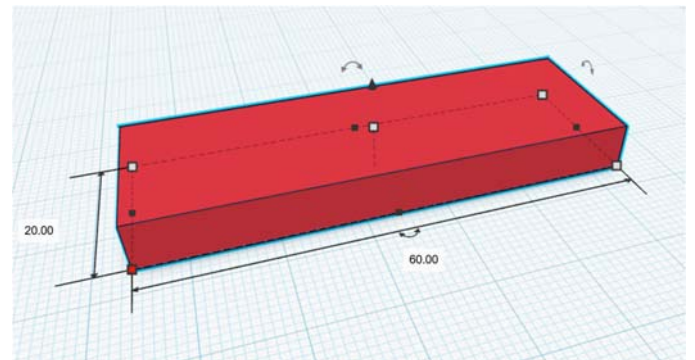
After creating a new 3D design and opening an empty working file, we will be working with "basic shapes" in the left menu.

**STEP 1:** Select "Box" and click on "Workspace" to place it on the workspace.

**STEP 2:** Once placed, a dialog will appear for setting parameters including the dimensions of the block - 60x20x6 mm.

**STEP 2a:** Alternatively, we can click on the block to view its dimensions and click on

them to adjust the dimensions numerically directly on the workspace.



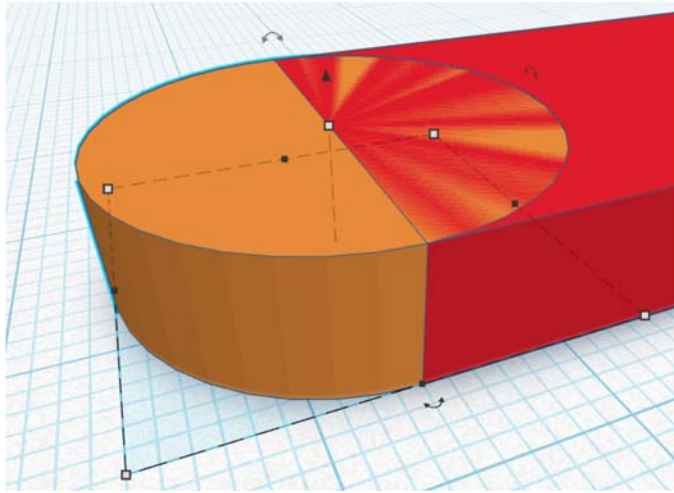
**STEP 3:** Now insert the "Cylinder" object on the "Workspace" using a similar procedure.

**STEP 4:** Set the dimensions of the cylinder to 20x20 mm and its height to 6 mm.

**STEP 5:** Move the cylinder so that it faces the shorter edge of the Block and its half is placed inside the Block.

**TIP:** For a neater design, it is possible to increase the number of "Walls" of the War in the dialog (from 20 to 40 for example), but

be careful about the correct and precise alignment to the box.



**STEP 6:** In order for the two bodies to merge into one we need to group them together. First, we select both solids in sequence (SHIFT click) and then select "Group" (CTRL + G) from the top menu. If we did this correctly, instead of two colors of solids, we now have one grouped single color.

**TIP:** We can always use "Ungroup" (CTRL + SHIFT + G) to split the bodies to edit them separately.

## 2 – Create a hole and cutout for text

If the basic shape suits us, we now create a hole for the key ring to be threaded onto and also a cutout for future text.

**K STEP 7:** Select "Cylinder" in the right menu and paste it on the "Workspace"

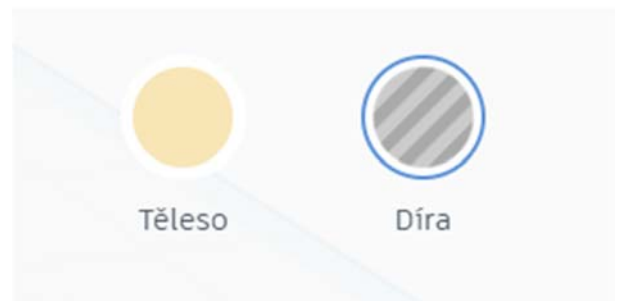
**STEP 8:** Adjust the size of the cylinder to 8x8 mm and the height to at least 6 mm (more is

better, as the cylinder will go through the base of the keyring)

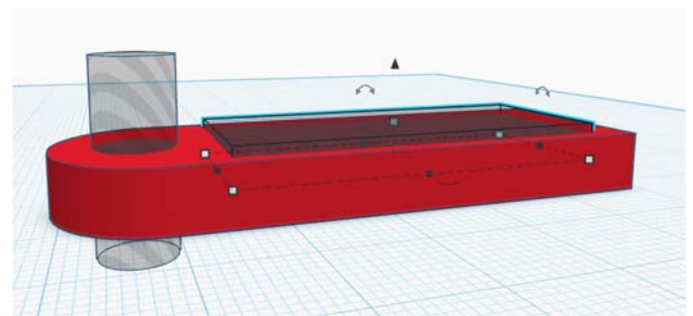
**STEP 9:** Next, place the new "Box" on the work surface

**STEP 10:** Set the dimensions of the Box to 40x16x6 mm (the actual height of the Box is not important, but it must be at least 3 mm).

**STEP 11:** Switch the two solids in their respective dialogs from "Solid" to "Hole".



**STEP 12:** Now move both bodies with the mouse so that the Cylinder goes completely through the pendant and the Block is embedded 3 mm deep into the pendant.

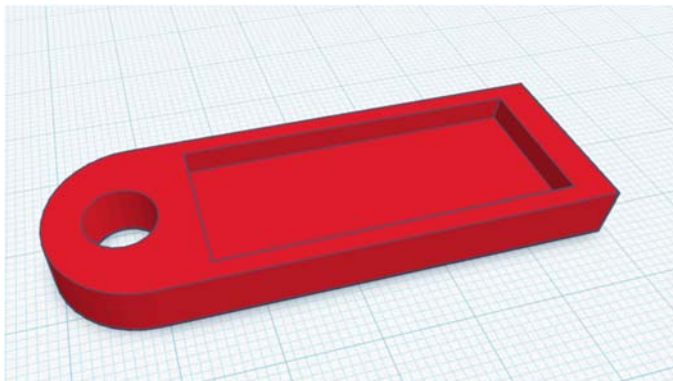


**TIP:** We can conveniently use the Views in the top left corner of the screen and the last item to get the right location: Switch between perspective and flat view.



**TIP:** You can also use the "**Align**" tool (L) in the top menu to adjust the alignment of two objects when selecting them.

**STEP 13:** All objects on the Workspace are now selected and Grouped. This will give us one solid with a hole and a depression.



### 3 – Adding text and finalization

**STEP 14:** From "**Basic Shapes**" insert the "**Text**" object into the "**Workspace**"

**STEP 15:** In the object dialog box, rewrite the text to your name or whatever you want the

tag to say. We can also select a different font from the menu.



**STEP 16:** Set the dimensions of the object to fit into the recess in the keyring, e.g.: 38x9x4 mm. Here it depends on the specific text and the dimensions may vary.

**STEP 17:** Place the text in the recess so that it lies on the bottom of the recess or is recessed into it. The text must not "levitate".

**STEP 18:** Finally, group the text and the tag together again to create one object for 3D printing.





## WORKSHEET 4



### TinkerCAD – Map project

This worksheet is used to create a quick but useful model where we can try working with imported shapes - in this case, states, which we will further modify using simple objects into a useful haptic aid. For a better overview, the different stages of the making process are divided into individual steps and are also marked in the video tutorial, which complements the whole process with a practical modelling demonstration\*

#### 1 - Preparation

##### Finding the state model

**STEP 1:** In TinkerCAD go to the **'Shape Generator'** section and select **'European Countries'**

**STEP 2:** Place the model in the centre of the Workplane by dragging it.

**STEP 3:** In the upper left corner, click on the automatically generated project name (e.g.

'Funky Project...') and change it to, for example, **'Map of France'**.

#### 2 – Inserting shapes to mark cities

We have the state ready now and in theory we can print it just as it is. However, it would be beneficial (especially for students) to put some additional information on it - for example, the location and descriptions of selected important cities of the state. In the video we show this with the example of France, but as we have already seen in the previous step, it is possible to use virtually any country.

**STEP 4:** In the right panel of TinkerCAD, switch to the **'Basic Shapes'** menu.

**STEP 5:** To mark cities you can use e.g. **Box**, **Cylinder** or **Cone**.

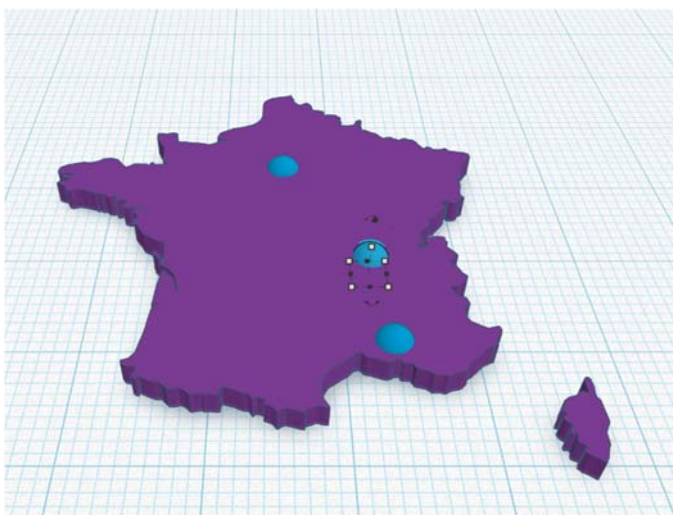
**STEP 6:** Drag the selected shape to the place where the city is located (e.g. Paris, Marseille, Lyon, ...).

**STEP 7:** Adjust the size so that it does not appear too large in relation to the outline of the state (small sizes, e.g. 3-5 mm, are recommended).

**STEP 8:** Check that the shape is at the correct height (preferably just above or aligned with the model surface, or 'recessed' into the model).

**STEP 9:** To speed up your work, we recommend using **Ctrl+C** (copy) and **Ctrl+V** (paste). However, make sure the size of the shape fits before you copy it so you don't have to adjust it unnecessarily on the copies.

**STEP 10:** Move copies of the shapes to other locations and gradually create labels for several major cities.



### 3 – Adding descriptions (texts) for cities

To make the map not just 'blind', we add labels to the shapes that are in the position of the city on the map.

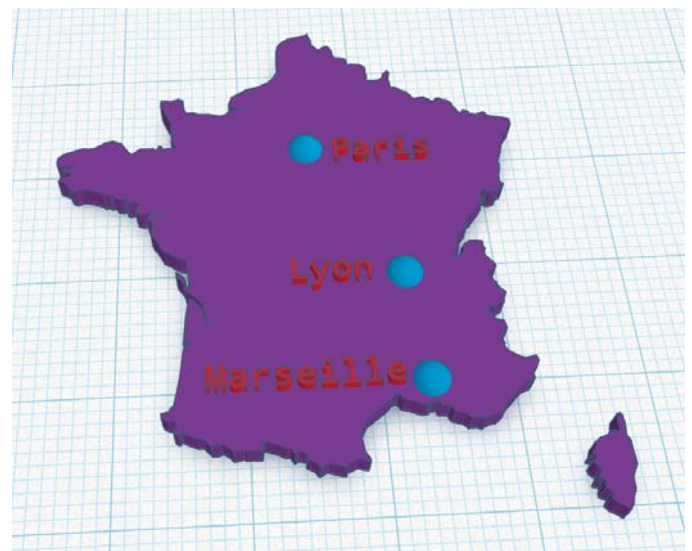
**STEP 11:** In the right panel, select Text (in the 'Basic shapes' category). Drag the text to the workspace next to the selected city.

**STEP 12:** In the 'Text' field, enter the name of the city (e.g. 'Paris').

**STEP 13:** Choose the Font and, if necessary, the Height to display the font well.

**STEP 14:** You can place the label directly next to the city or next to the 'pin'.

**STEP 15:** For other cities, again use copy (Ctrl+C, Ctrl+V) and just change the text according to the name of the city.

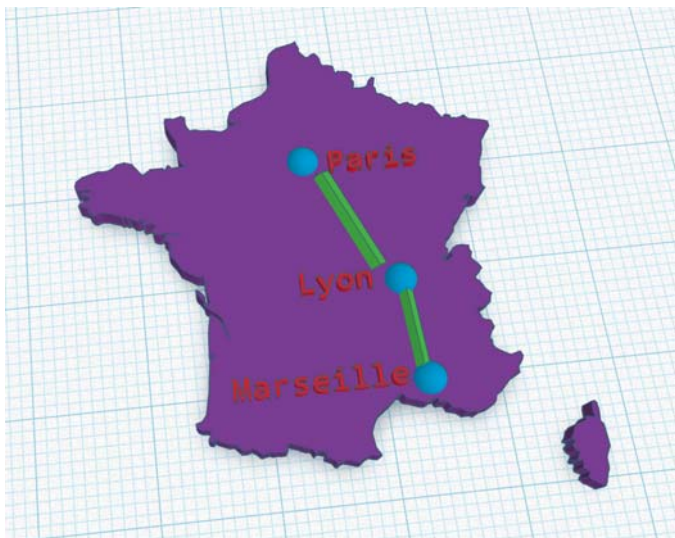


## 4 – Optional: adding transport arteries between cities

Such a map can be decorated as desired. Here we will try for example to connect cities that we already have on our model.

**STEP 16:** In TinkerCAD you can create lines in different ways. For simplicity, you can use the **'Roof'** or a simple cube (**Box**) that we will stretch.

**STEP 17:** Connect cities where it makes sense (e.g. the main transport artery Paris - Lyon, Lyon - Marseille, etc.).



**STEP 18:** Rotate the line (cylinder or rod) to the desired direction after insertion using the controls.

**STEP 19:** Make sure the connection is in level with the surface of the map so that it can be printed and does not 'hover' in the air above the map!

**TIP:** At the end of the modeling process, we combine everything into one unit using the **Group tool**, so that the finished model does not break when moving or exporting



## WORKSHEET 5

INTERMEDIATE

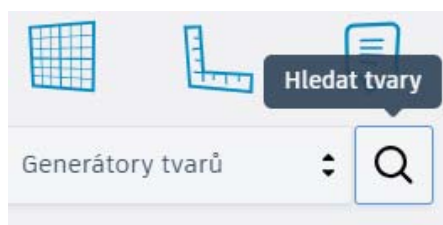


### TinkerCAD – Making fridge magnets

In this worksheet, we will work on creating a simple magnet together - for example, on a magnetic whiteboard in the classroom, on a locker door, or at home on the fridge.

We will use the preset modifications of special shapes. However, you can also use **Sketch** or **Scribble** to create your own and completely original magnets.

**TIP:** For easier searching between modifiable shapes, you can use the magnifying glass. For faster searching for shapes, don't forget to mark them with an asterisk, so it's easier to get to them later via the Favorites section.



**KROK 1:** From the right panel of the object library, click (LM) on the **Shape Generator**

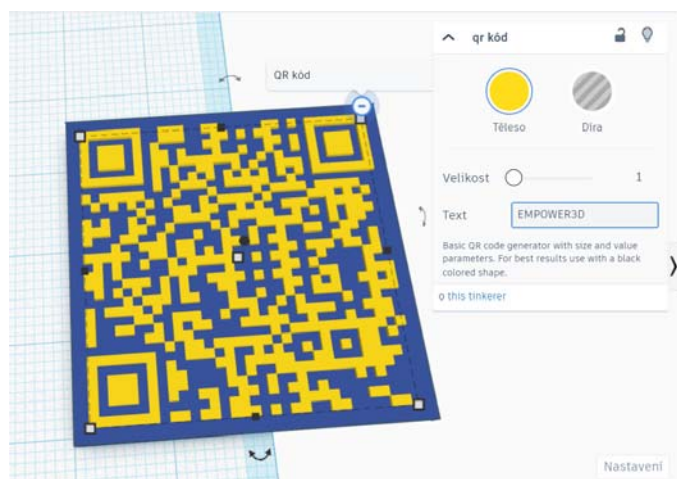
section.  Generátory tvarů

**KROK 2:** In this section we find objects named **QR code**, **Text bubble**, **Dummy** and **pie chart**.



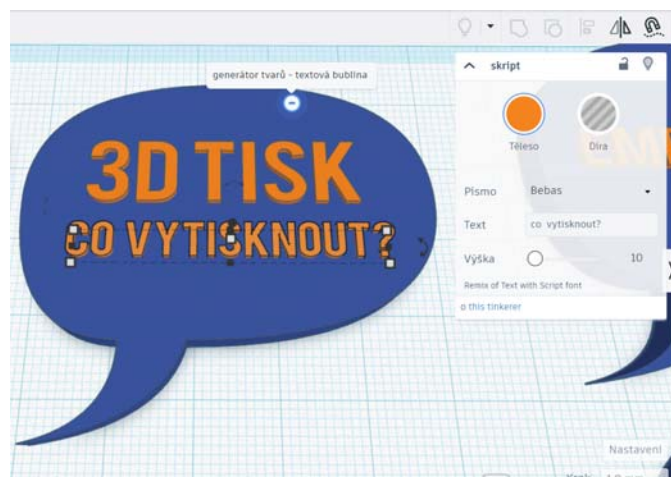
**KROK 3:** For each object we test its modification according to the given parameters:

**QR CODE** – When creating a QR code, add any URL or plain text to the Text field. In order to print the QR code properly, we will model a backing plate from the basic shape of the Box, for example with the size of 36x36x2mm.



Before printing, don't forget to set the color change in PrusaSlicer from the layer with the code itself (in other words - the plate will be one color, while the code will be another color).

**TEXT BUBBLE** – After modifying the text bubble, add the text from the Script shape, choose the font type Bebas and write the text on the bubble, which will serve as the TO DO sheet of the bubble magnet - we chose the task magnet for the planned 3D prints 😊.

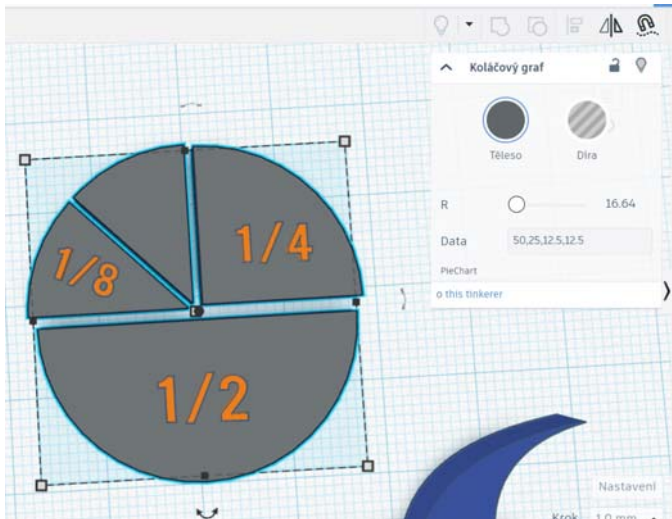


**FIGURINE (CARCASSONE)** – Use the shape generator to try making different variants of the Carcassone figures, which you can print out to create a magnetic set. Do you want a king, a cob, a princess or a catapult? 😊 Don't forget to model a small support in the form of a backing card for some of the pieces, so that the magnets (ears of corn, for example) don't fall apart during printing.



**PIE CHART** – A pie chart is another great shape that can be used to create, for example, fraction magnets for math. In the

*Data* field, set the desired type of fractions, e.g., division by values of 50 (one half  $\frac{1}{2}$ ); 25 (one quarter  $\frac{1}{4}$ ); 12.5 and 12.5 (two eighths  $\frac{1}{8}$  and  $\frac{1}{8}$ ). For better clarity, you can add text to the individual pieces to label the given parts of the fractions.



## Magnet printing + post-processing → room for creativity

### QR CODE

When printing a QR code in *PrusaSlicer*, don't forget to set the Color Change from the layer with the code itself, so that the bottom plate is printed in one color and the QR code in another. During printing, we recommend choosing contrasting colors (e.g., black and white, dark blue + yellow, etc.) – this will make the code more readable by the code scanner.

## TEXT BUBBLES, PIE CHARTS

When setting up printing in *PrusaSlicer*, try setting *Color Change* for the layer with text to ensure a multicolored final product..

**MEEPLE (CARCASSONE GAME PIECE)** The printed pieces can be painted, decorated with glitter, embellished with small beads (e.g., princess dresses, royal crowns), etc. After decorating the pieces, be sure to seal them with clear hairspray to prevent the colors from rubbing off and the components from coming loose (e.g., glitter falling off).

With a pie chart, you can print each slice in a different color to distinguish between the different types of fractions.

Glue the finished magnet to a piece of magnetic foil, or attach it using superglue, double-sided adhesive tape, or a hot glue gun\* to any old, worn flat magnet—this will provide a base for attaching it to a metal magnetic surface instead of foil.



**And magnets of various shapes are born**



**Explanatory notes and comments:**

LM – left mouse button, left mouse click

RM – right mouse button, right-click

Dimensions = XY axis = length x width (X axis  
x Y axis)

**\*Note:** When gluing with a hot glue gun, it is important to glue very quickly and carefully and always apply a small amount of glue so that the surface of the magnet is not deformed by heat



## TinkerCAD – Bookmark

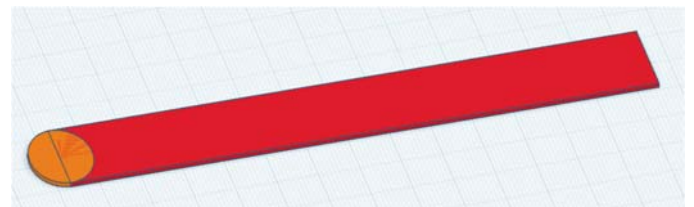
A 3D printed bookmark is a practical and versatile accessory for marking pages. Thanks to 3D printing, bookmarks can be created with embossed patterns and personalized designs. In addition, it provides further scope for possible improvements such as moving parts and functional elements like clips or rulers. In this tutorial, we will make a simple bookmark..



### 1 – Bookmark base shape

**STEP 1:** In the basic shape, we will start by determining the approximate dimensions of the bookmark we want. From "Basic Shapes," we will insert a "Box" and set its dimensions so that it is low/thin and sufficiently long – 140x20x1 mm. A thickness of 1 mm should be sufficient for the strength and flexibility of the bookmark..

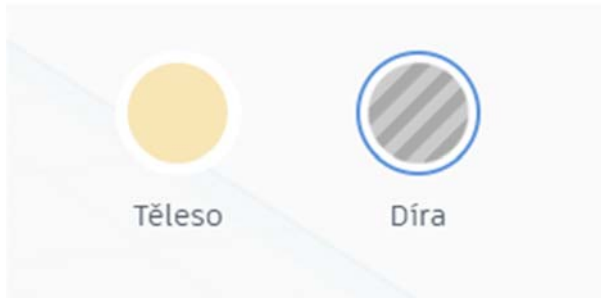
**STEP 2:** Place the "Cylinder" on the work surface and use it to round the bottom of the bookmark ( in a similar way as in the worksheet for the key ring). The cylinder will also have a thickness of 1 mm and can be adjusted to an oval shape of 20 x 15 mm.



**STEP 3:** Group both objects (CTRL + G).

## 2 – Bookmark design

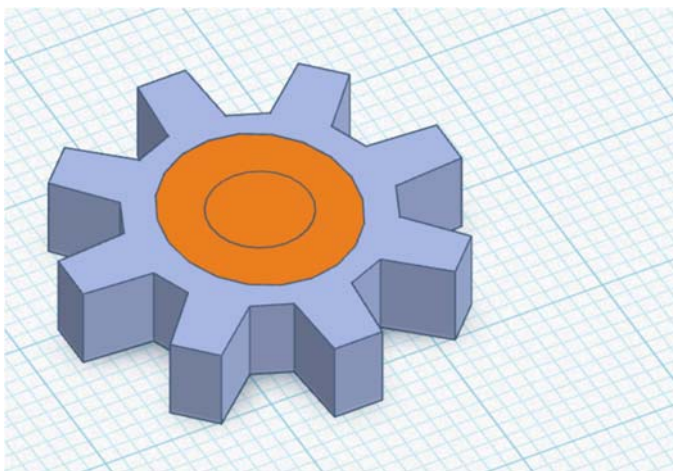
We can improve the appearance of the flat part by adding other elements to it. We can also create notches, but to keep our tab thin, we will use settings such as "Hole" after inserting objects and create holes.



**STEP 4:** From the "**Hardware**" category, we will place a "**Gear Wheel**" on the **Workplane**.

**STEP 5:** Since the gear wheel has a hole in the center, which would cause us to print a part that is not part of the bookmark, we will also insert a "**Cylinder**."

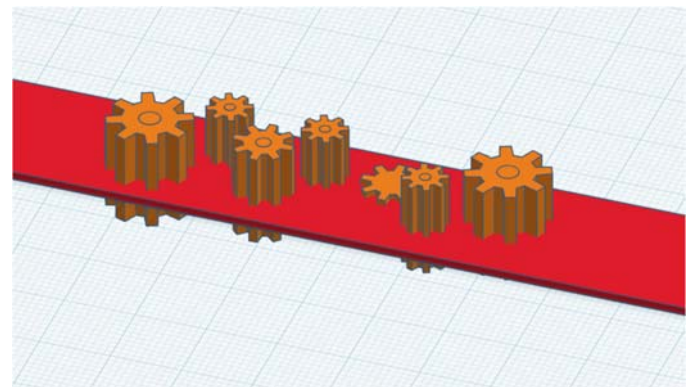
**STEP 6:** Place the "**cylinder**" in the center of the gear wheel and set it to the same height as the gear wheel..



**STEP 7:** When we now "**Group**" both objects (CTRL + G), we get a gear wheel without a hole.

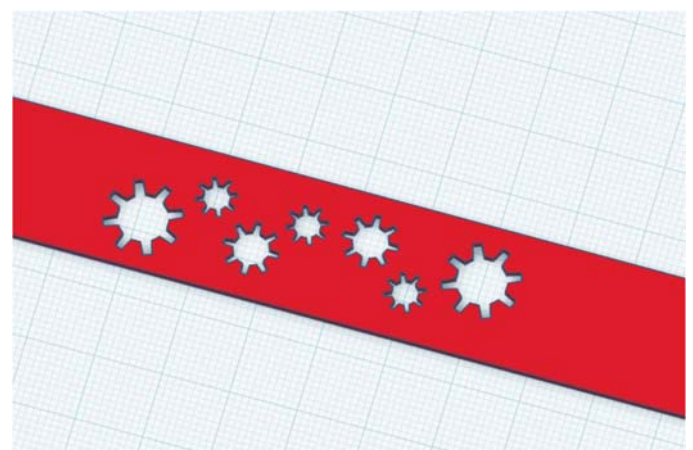
**STEP 8:** Copy multiple objects created in this way (CTRL + C, CTRL + V).

**STEP 9:** We will place the gears on our bookmark as follows. The height of the objects is not important, they just need to pass through our bookmark.



**STEP 10:** We will set the gears as "Hole".

**STEP 11:** Group all objects (CTRL + G).



**TIP:** We can use any objects to create cutouts, including those imported into

TinkerCAD from <https://www.svgrepo.com/> (see the Story Cube worksheet).

### 3 – Bookmark header

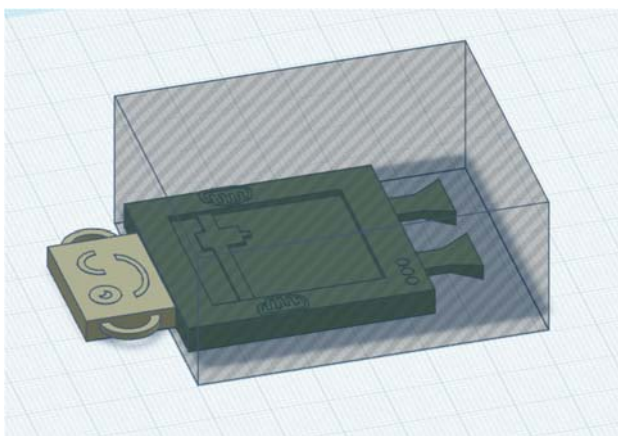
In the upper part of the bookmark (i.e., the part that we did not round with the cylinder), we can create any "larger" design element. This part of the bookmark will stick out of the book and can therefore be taller. For our purposes, we will use a robot (see the EMPOWER3D Robot worksheet).

**STEP 12:** In Tinkercad, click on the "**Import**" button in the upper left corner.

**STEP 13:** Next, choose "**Select File**" and find the robot's STL file on your disk..

**STEP 14:** In the following, we can readjust the size. And click on Import.

**STEP 15:** We only want to use the robot's head, so the easiest way to achieve this is to insert a new "Box" into the scene, set it as a "Hole," place it over the robot's body, and then select "Group" (CTRL + G).

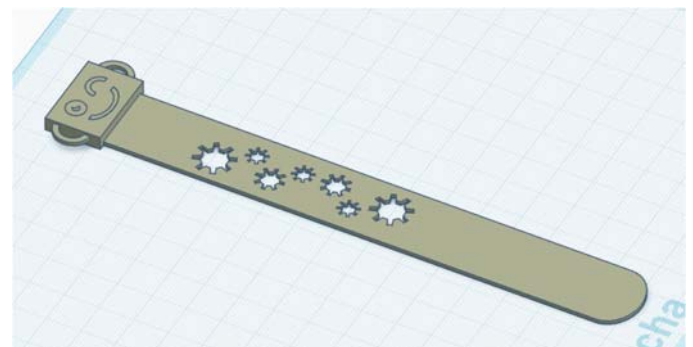


**TIP:** The benefit of this process is that we can use it on any imported 3D objects and thus obtain part of the model even from an object downloaded from Thingiverse or another database.

**STEP 16:** If necessary, adjust the size and height of the resulting robot head.

**STEP 17:** Place the robot's head so that it touches (or is embedded in) our bookmark..

**STEP 18:** Now, let's "Group" all the objects (CTRL + G).



## TinkerCAD – Mobile phone stand

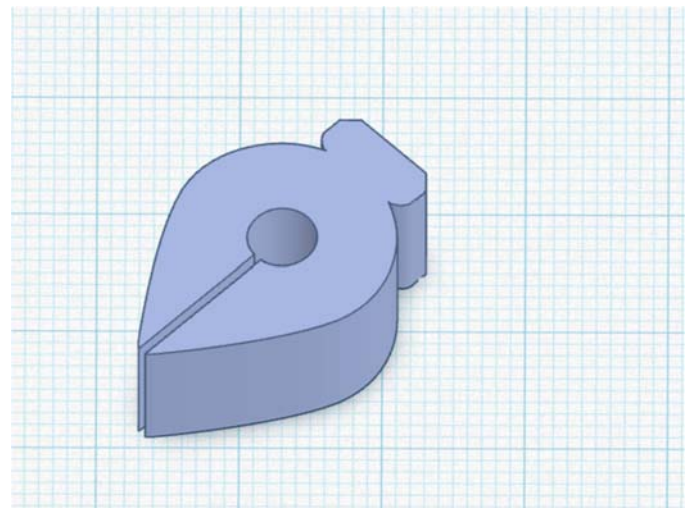
The 3D printed mobile phone stand is a practical holder that allows you to comfortably watch content or charge your phone. It can be adjusted to different angles, device sizes, and design preferences. Thanks to 3D printing, you can have a stand that is completely customized to your design.



### 1 – Base shape of the stand

We will use the "**Sketch**" tool to create the basic shape of the stand.

**STEP 1:** From "Basic Shapes," select the "Sketch" tool and place it on the "Workplane".



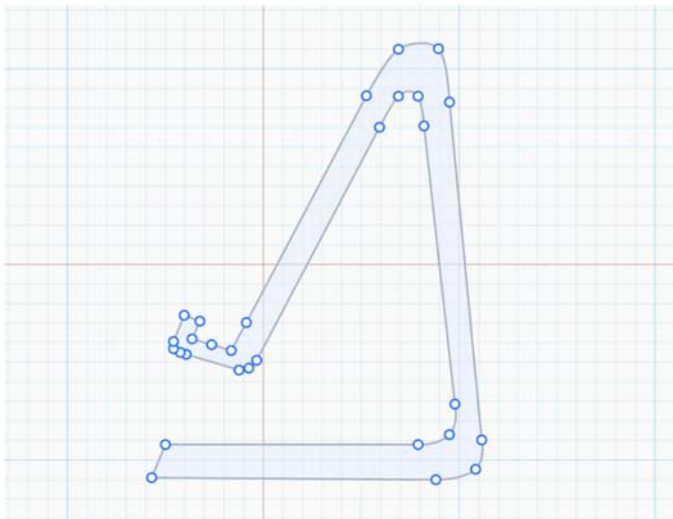
TinkerCAD will now switch to curve mode, in which we create a 2D "sketch" of the shape, which will then be extruded into 3D.

The left menu contains three tools for creating straight lines, Bézier curves, and erasing.



**STEP 2:** Using the "Create Line" (1) or "Create Bézier Curve" (2) tool, click to create the basic shapes of the stand..

**TIP:** An easier way for beginners is to click on the square shape using the "Create Line" tool and then edit it further.



Once we have the basic shape of the stand profile, tools for "select and move" and "add and remove points" will appear in the left menu. We can use these when editing and fine-tuning the shape of our stand profile.



The bottom menu is equally important, as it contains tools that allow us to determine the course of the curve at the selected point. There are three options:

- Corner for sharp curve breaks
- Smooth for symmetrical rounding
- Remove handles for asymmetrical option to set each handle separately.

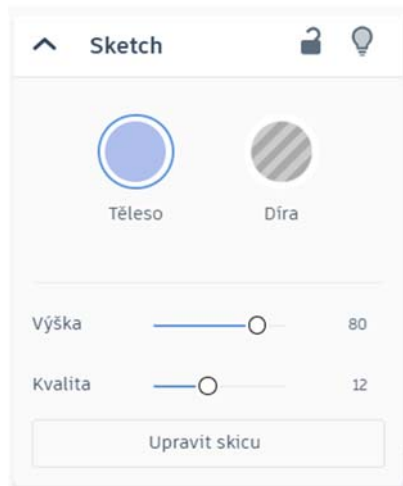


**STEP 3:** We will adjust the shape of the curve until it suits us completely.

**TIP:** If necessary, it is advisable to set a finer step in the lower right corner for more precise movement of points and handles.

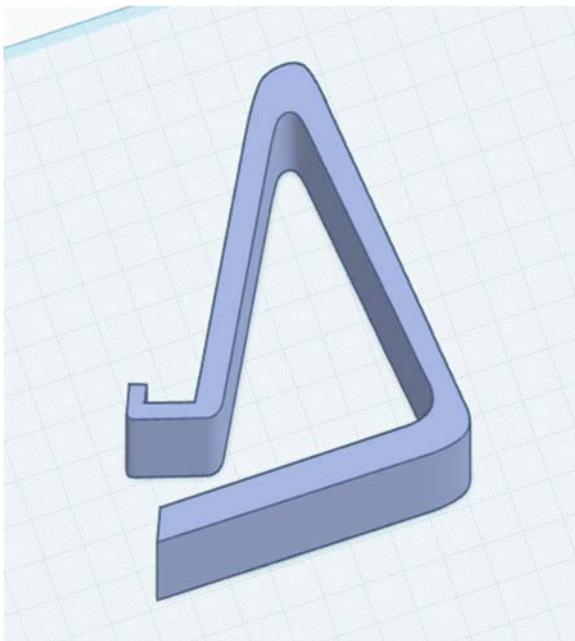
**STEP 4:** Once we are satisfied with the curve, select "Finish Sketch" in the upper right corner to return to the standard TinkedCAD environment.

**STEP 5:** For the resulting Sketch, we set its extrusion height (80 mm) and, if necessary, its quality.



**TIP:** If we are not satisfied with the design, we can return to working with curves at any time by clicking the "Edit sketch" button.

**STEP 6:** We will adjust the height of the object, as well as other dimensions, so that it fits your mobile phone (or tablet or other device).



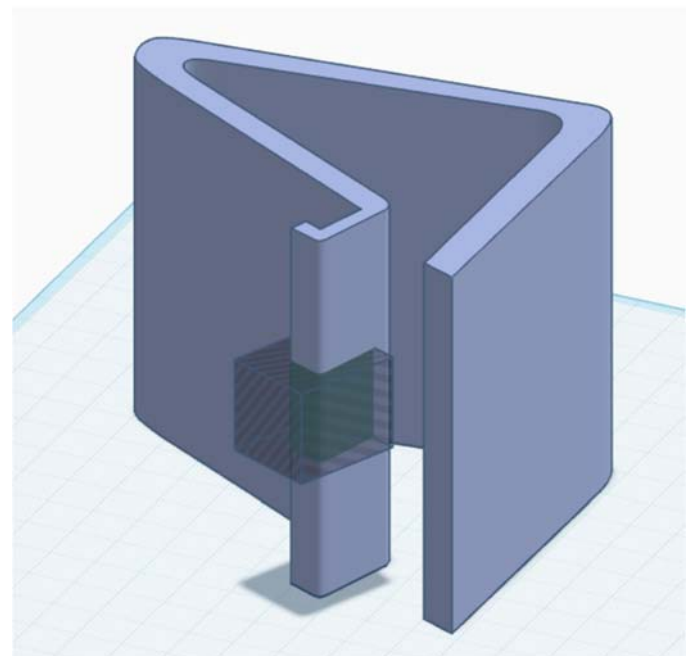
## 2 – Cable hole and other modifications

In the part where the charging connector will be located on the phone, we will make a hole in the stand for pulling it through. We will also make a hole in the back of the stand – this will allow us to pull the cable through to the back and also save a little printing time and material.

**STEP 7:** We will insert a new "Box" onto the "Workplane."

**STEP 8:** We will adjust the dimensions of the box and its position so that it is located in the required opening.

**STEP 9:** Set the "Hole" mode for the Box.

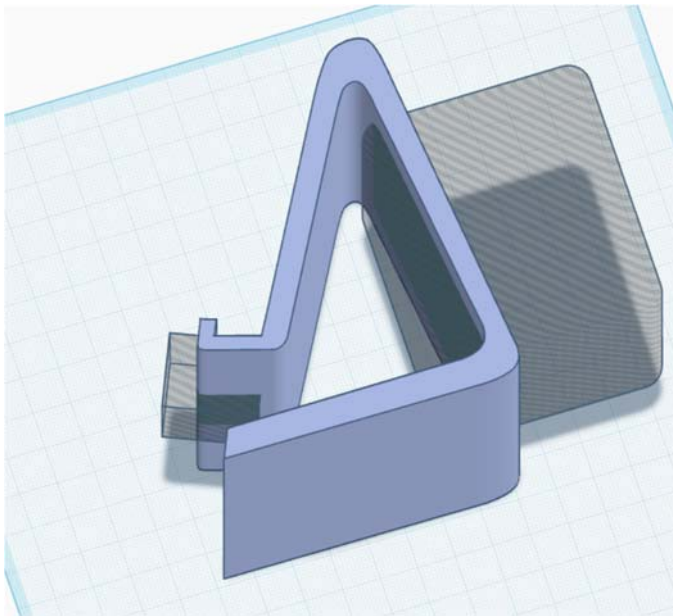


**KROK 10:** We will insert a new "Box" onto the "Workplane."

**STEP 11:** We will adjust the dimensions of the box and its placement so that it is located in the necessary opening in the rear part of the mobile phone stand.

**STEP 12:** For the box, set the radius of the rounded edges to approx. 6 mm (or as needed).

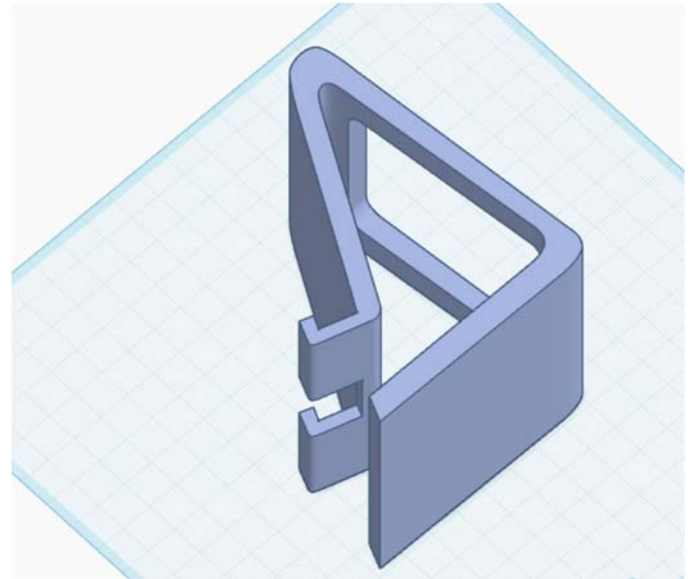
**STEP 13:** Set the "Hole" mode for the Box.



**STEP 14:** Select all parts of the phone stand and "Group" them (CTRL + G).

**TIP:** With a grouped shape, we can no longer edit the sketch, but we can split the group again (CTRL + SHIFT + G) and then edit the sketch if necessary..

**TIP:** There are no limits to design ideas, so we can also make holes in the back where the phone will rest—this will improve the phone's cooling—or emboss a shape similar to the worksheet Bookmark or Story cube..



**TIP:** It is better to leave our stand in the position shown in the picture for printing. It will still need supports, but there will be fewer of them, they will be easy to remove, and they will not affect the appearance of the stand.



## WORKSHEET 8



### TinkerCAD – Cookie cutter

A 3D-printed cookie cutter for gingerbread or other cookies allows you to create original shapes. Thanks to 3D printing, you can easily customize the size, design, and details to your liking. It is lightweight, durable, and suitable for repeated use when baking..



#### 1 – Base shape of the cutter

First, we will create the basic shape of the cookie cutter – in our example, we will use a heart shape.

**STEP 1:** From "Basic Shapes," insert the "Heart" shape onto the "Workplane."

**STEP 2:** We will adjust the basic size of the cookie cutter to 70x65x10 mm. (Of course, we can adjust the size according to our liking.)

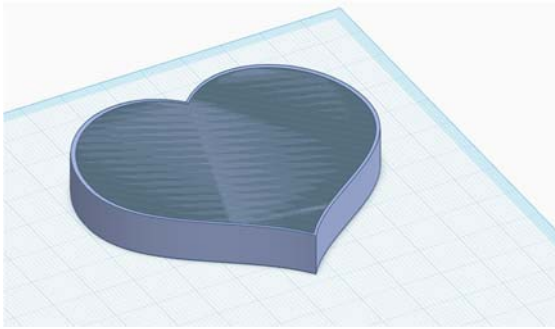
**STEP 3:** To obtain the outline of the shape for cutting, we "Duplicate" our shape (CTRL + D).

**STEP 4:** We will reduce the duplicated shape to 68x63x10 mm.

**STEP 5:** Set the "Hole" mode for the duplicated shape.

**STEP 6:** Align both heart shapes so that they are inside each other.

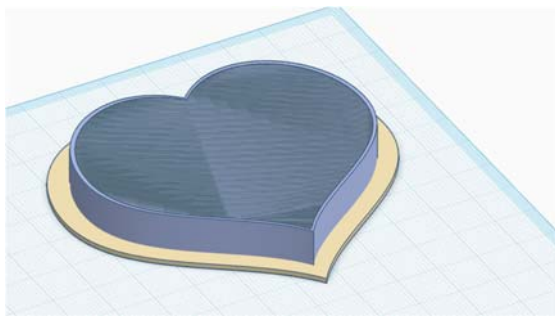
**TIP:** We can use the "Align" tool (L) for alignment.



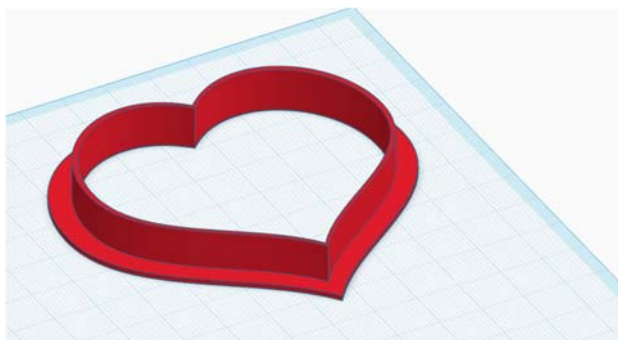
**STEP 7:** Duplicate the outer heart (the one that is not the "hole") once more (CTRL + D).

**STEP 8:** Set the size of the newly duplicated shape to 80x75x1 mm.

**STEP 9:** We will align the heart again to the center of the previous shapes.



**STEP 10:** Now group all three heart shapes (CTRL + G) to obtain the base of the cookie cutter, which is ready to be printed and used.



**TIP:** Instead of a heart shape, we can use any suitable shape from TinkerCAD or import a shape from an online source. For example, vector shapes imported from <https://www.svgrepo.com/> are suitable. (see the Story Cube worksheet).

## 2 – Stamp part of the cutter

We can improve the cookie cutter by placing additional shapes inside it that will act as stamps in the dough, so that our heart will have a motif imprinted in the dough after cutting.

Let's create a simple motive for a 3D printer print head printing hearts.

**STEP 11:** Place 2 Boxes and 1 Heart on the "Workplane."

**STEP 12:** We set the size of the first "Box" to approx. 15x9x7 mm.

**STEP 13:** Set the size of the second "Box" to approx. 3x7x7 mm.

**STEP 14:** Set the size of the "heart" to approx. 10x11x7.

**TIP:** The height of 7 mm for all three bodies corresponds to the height of 10 mm for the cookie cutter. This means that if the dough is 4 mm thick, we will get an approximately 1 mm deep impression in the dough. We must adjust the height of the elements to the height of the dough (or, conversely, the height of the dough to the cookie cutter).

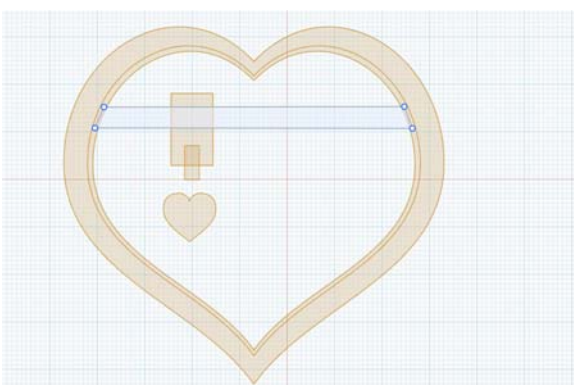
**KROK 15:** We place all three elements appropriately inside our heart.



Now we will add the arm on which the print head is located. We could simply use a "Box," but it would not fit the heart shape at the edges, so we will use "Sketch" instead.

**STEP 16:** Place the "Sketch" shape from "Basic Shapes" onto the workspace inside the heart, and TinkedCAD will switch to sketch mode.

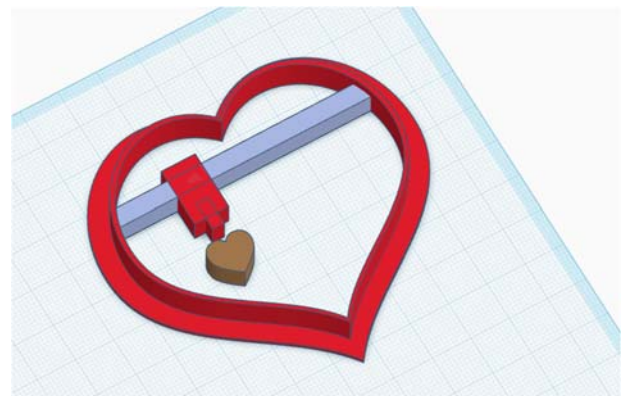
**STEP 17:** We will use the "Create Line" tool (1) to create a quadrangle that passes through the print head and whose edges are inside the cutting part of the cutter.



**TIP:** For more precise positioning, we can set a finer "Step" in the lower right corner.

**STEP 18:** Select "Finish Sketch" and return to the 3D environment.

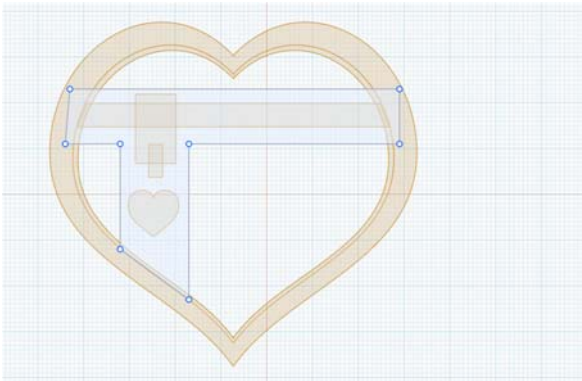
**STEP 19:** Adjust the height of the new shape to 7 mm and check that it is in the position we need.



The decal part is now ready, but all parts are not connected, so we will use the "Sketch" tool to create a collar around the decal parts again, just like the heart has..

**STEP 20:** Place the "Scribble" shape from "Basic Shapes" onto the workspace inside the heart, and TinkedCAD will switch to sketch mode..

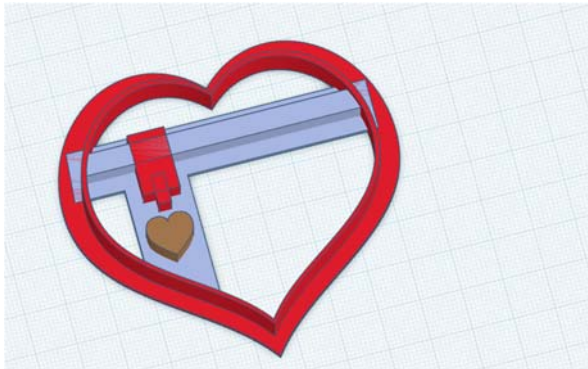
**STEP 21:** We will use the "Create Line" tool (1) to create an n-gon so that we get an offset collar around the print head and the imprinting part of the cutter..



**TIP:** For more precise positioning, we can set a finer "Step" in the lower right corner.

**STEP 22:** Select "Finish Sketch" and return to the 3D environment.

**STEP 23:** Adjust the height of the new shape to 1 mm and check that it is in the position we need.



**STEP 24:** Now we will "Group" all objects (CTRL + G) and our cookie cutter is ready.





## WORKSHEET 9

ADVANCED



### TinkerCAD – Creating a robot from a primitive

In this worksheet, we will work together on a specific project to explain step by step how to model in the TinkerCAD environment and model the EMPOWER3D robot. For a better overview, the various stages of creation are divided into individual steps and are also marked in the video tutorial, which supplements the entire process with a practical demonstration of modeling\*.

#### 1 - Creating the basic framework

In order to create both simple and more complex projects, it is necessary to learn how to work with the basic tools, objects, and functions offered by TinkerCAD. For this purpose, we will work together to build a model of the EMPOWER3D robot from scratch, which even primary school pupils will be able to create and modify themselves.

**TIP:** The model and procedure described here are only examples – it is entirely up to you whether you decide to implement them in detail with your students or whether you decide to assign your students the task of creating their own robot in a similar way, using, for example, other available elements offered by TinkerCAD. You can also modify the finished robot model into a key ring or magnet 😊.

**TIP – WITH DIMENSIONS AND WITHOUT:** The dimensions of the individual parts are only approximate and serve to teach precise dimensioning – you can choose your own dimensions or model entirely "by eye" and try out working with objects and tools when creating a robot.

Let's start with the basic shape of the robot's body. Before starting the project, don't forget to name your project appropriately – for example, "ROBOT EMPOWER3D."

## 1.1 – Head creation

**STEP 1:** From the Basic Shapes menu, select the Box shape (LM) and place it on the workspace (LM). If necessary, you can also change the color of the cube, for example to green, for better orientation while working (LM on Body in the dialog box and select a shade).

**STEP 2:** Clicking on the cube (LM) displays the dimensions in millimeters – the so-called coordinates. These can be entered manually, or using the small white squares in the corners of the coordinates, the size of the cube can be changed freely in all axes using the mouse (LM).

To create the robot's head, select the dimensions 30x40mm. Do not change the height for now and leave it at the original size of 20 mm (any changes to the height of the object will be made after grouping the head with the torso).

## 1.2 – Torso creation

**STEP 3:** Repeat steps 1 and 2 and set the size of the robot's body to 80x70mm with a height of 20mm.

## Body frame grouping

### (alignment and connection of head + torso)

Now we will align and group both parts of the body. Select the Head Cube (LM) and move it towards the robot's torso.

### Aligning objects:

**STEP 4:** Once both parts of the model are touching each other, select both objects (click LM + hold LM → drag the cursor across both objects to select all objects; or click LM on one of the objects + hold Shift + click LM on the second object).

Then select the **Align** function in the upper right bar and align both objects so that the head is centered exactly in the middle and touches the upper edge of the torso. We do this by clicking on the circular indicators that appear at the edges of the objects when aligning them – by switching between them, we achieve the desired position of both parts of the robot in relation to each other.

### Grouping and ungrouping objects:

**STEP 5:** Once the head and torso are in place, everything needs to be joined together – repeat the selection of both objects from step 4 and click on the Group button (CTRL+G). If you chose a different shade for the head cube at the beginning, it should now match the color of the torso.

**STEP 6:** We will check the "joints" and also the overall size of the head and torso. If we don't like any of the parts after merging them, we can disconnect both parts again by selecting the robot's body (click LM) and then clicking the **Ungroup** button (CTRL+SHIFT+G), and we can edit each of them separately.

Once we are satisfied with everything, we will put the whole body back together and start creating the robot's body parts.

## 2 – Creation of body parts

We have prepared the body frame, now we will start modeling individual parts of the robot's body, such as arms, legs, eyes, mouth, and ears. For the modeling itself, optimal printing, and strength of the final print, antennas are not included in the project.

### 2.1 – Creating the Legs

**STEP 7:** We have the basic shape of the body, now let's start modeling the robot's legs. Here we will combine and modify two different shapes – a **Box** and a **Cone**. Selecting from the object menu, we will first transfer the Box to the Workplane and adjust its square base in the XY axis to a size of 9x9mm with a height of 15mm.

Then place the Cone on the Workplane and adjust its square base on the XY axis to a size of 15x15mm with a height of 8mm.

**STEP 8:** Select (LM) both objects and use the **Align** tool to center them so that the cube forms the base of the robot's foot, while the Cone forms an imaginary shoe on the robot's foot. →

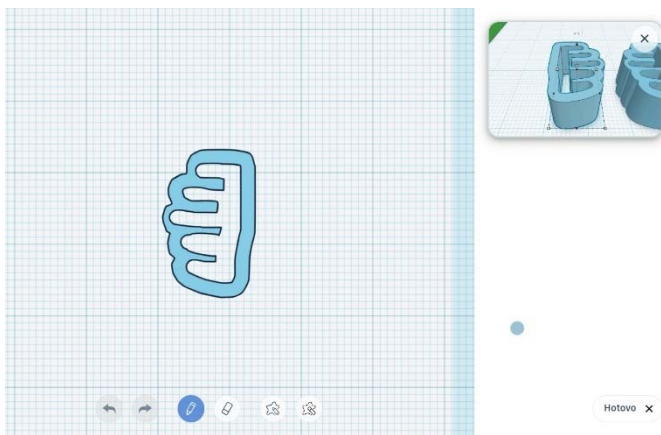
Once the leg is complete, use the Merge function to join the two pieces together. To create the second leg, copy it using the Copy function (CTRL+C) and paste the copy (CTRL+V) onto the Workplane..

**TIP:** We can use the **Duplicate and Repeat tool** (CTRL+D) in the same way. After selecting the leg (LM) and clicking on the function, simply drag the new copy into the space from the original leg (LM on the original leg → click LM on the Duplicate and Repeat function → click on the original leg and drag the copy of the leg into the space).

### 2.2 – Creating hands of the robot

**STEP 9:** To create the hands, we will use the **Scribble** tool, in which we will draw the robot's hand according to our needs. If necessary, we will adjust the shape of the hand directly in the tool, confirm the finished sketch, and place it on the Workplane. We will adjust the size of the hand to approximately 10x15mm in the XY axes with a height of 3mm (the width and

length of the hand is individual – it depends on the shape of the sketch; the size and shape of the hand can be adjusted later when attaching it to the robot's body). Copy the finished hand using the Copy function (CTRL+C) and paste the copy (CTRL+V) onto the desktop, or duplicate it (CTRL+D). Rotate this copy 180° around the X axis using the arrows with the protractor (after clicking on the shape of the hand), or more simply using the **Mirror** function.



## 2.3 – Creating ears

**STEP 10:** Let's start creating the ears. Select the **Tube** shape and place it on the work surface. Reduce the height to 7.5 mm; it should have dimensions of 20 x 20 mm on the XY axis. In the shape properties, increase the number of tube walls to 64 and set the tube wall thickness to 2.5 mm..

Using a **box** shape, which we will label as a hole, and adjusting its size so that it exceeds the dimensions of the pipe, we will cut

through the pipe to create a semicircular shape for the ears . We do this using the **Group** tool, where we join the cube together with the pipe in its middle, thereby hiding the hidden piece of pipe after joining.

To create the second ear, copy it using the **Copy** function (CTRL+C) and paste the copy (CTRL+V) onto the Workplane, or duplicate it (CTRL+D). Rotate this copy 180° around the X axis using the arrows with the protractor (after clicking on the hand shape), or more simply using the **Mirror** function.

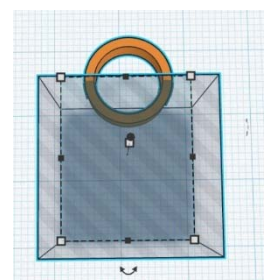
## 2.4 – Creation of eyes and mouth:

Here we will use the Cylinder, Tube, and Box shapes. For both shapes—tubes and cylinders—we will set the number of faces to 64 in the properties.

### Creation of eyes:

#### Winking eye:

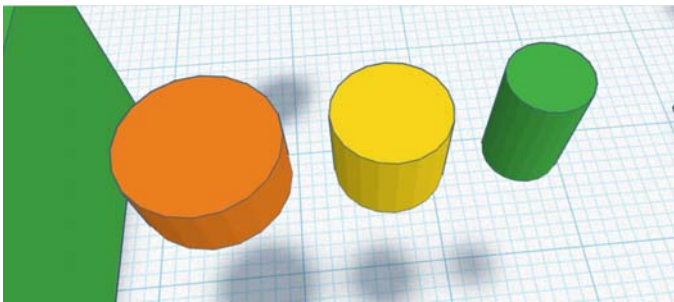
**STEP 11:** Select the **Tube** shape and set the dimensions in the XY axis to 10x10mm with a height of 3mm and a wall thickness of 2mm.



To create a **blinking eye**, repeat step 10 from creating the ear by connecting the box and tube together in the middle. Rotate the eye using the **Mirror** tool on the Y axis.

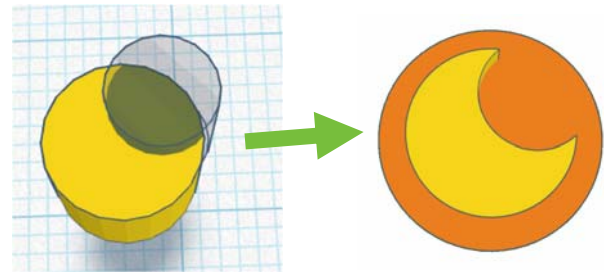
**STEP 12:** To create an **open (full) eye**, we need 3x **Cylinder**:

- First – **main and largest cylinder** (body)  
– **7x7 mm** with a height of **3 mm**;
- Second – **smaller central cylinder** (body)  
– **5x5 mm** with a height of **4 mm**;
- Third – **the smallest cut-out cylinder** (hole)  
– **3,5 x 3,5 mm** with height of **5 mm**.



Place the smallest cutting cylinder set as a **hole** in the upper right quarter of the center cylinder so that it creates a central "moon" in the future open eye of the robot (if necessary, reduce the Step to 0.5 mm for smoother movement across the surface).

Then, we'll join both cylinders using the **Group** tool. We'll place the resulting shape in the center of the main cylinder (using the **Align** tool to center it) and join the entire eye together (using the **Group** tool).



**TIP:** The entire process of creating a full eye can be simplified to a single cylinder, or have pupils create eyes using the **Scribble** tool.

### Mouth creation:

**STEP 13:** Select the **Tube** shape and set the dimensions in the XY axis to 18x15mm with a height of 3mm and a wall thickness of 1.5mm.

To create the mouth, we will use the shape of a **Box** with a Tube and repeat **step 10** by connecting the **Box** and **Tube** together in the middle..

## 3 – Creation of a 3D printer inside the robot's body

### 3.1 – Axis with extruder

We have prepared the individual parts of the body, so let's move on to the last part – creating a 3D printer inside the robot's torso. We will use the **Box** shape to create the printer axis and extruder.

**STEP 14:** To create an axis with the printer extruder, we need 3x Boxes:

- First – **main axis of the 3D printer** (body) – **50x5 mm** with height of **5 mm**;
- Second – **extruder body** (body) – **7x12 mm** with height of **5 mm**;
- Third – **extruder hotend** (body) – **2 x 2,5 mm** with height of **5 mm**.

After modifying all three cubes, we will connect the extruder body with the hot end using the Group tool. Then we place this part on the right side of the main axis (the first modified cube), or at our own discretion, and also connect it to the extruder (**Group tool**).

### 3.2 – 3D printer body

**STEP 15:** Select the **Box** shape and adjust it to a size of 45x50mm with a height of 8mm.

Then change the Box to a **hole** and place the Box in the center of the robot's torso.

We will embed the Box into the body to its height (i.e., 8 mm down into the body) and connect it to the body using the **Group** tool to create a recess for the axis and extruder.

## 4 – Completion: robot assembly – attaching body parts to the robot torso

All parts are ready, now we will assemble everything and put it in place. When assembling the individual parts, we proceed from the head towards the feet, but it is entirely up to you in which order you assemble the individual parts 😊.

**TIP:** When placing the parts, do not forget to check that they are firmly attached to the surface of the robot body so that no part of the robot "floats" in air. If you are not sure about the exact recess, you can recess all parts by 1 mm in depth – i.e. into the interior of the robot body.

### 4.1 – Ear placement:

**STEP 16:** We will separate the torso (2x in a row using the Ungroup function) and center the ear with the robot's head on each side of the head (using the Align tool). Then we will reconnect the head with the ears to the entire robot torso.

**ATTENTION** – it is necessary to check that the recessed box – the body of the 3D printer – from step 15 has also been reconnected to the body.

### 4.2 – Creating and positioning the robot's face:

**STEP 17:** Move all parts of the face (eyes and mouth) to the robot's head and center them as you see fit so that the face is centered (you can use the **Ruler** tool and the **Align** function). Then select the eyes and mouth and join them together (**Group** tool).



### 4.3 – Fitting the 3D printer into the torso:

**STEP 18:** Now insert the axis with the 3D printer extruder into the prepared hole inside the robot's body. Position the axis so that its ends are embedded in the sides of the robot's body and do not stick out anywhere. Place the axis in the upper part of the body, but it is possible to move it closer to the center if necessary.

### 4.4 - Hand positioning:

**STEP 19:** Place the arms on either side of the opening for the 3D printer – adjust their size as needed so that they do not protrude beyond the edge of the robot's torso, which could cause problems later when printing the finished model. We place the hands in the upper half of the body, but they can also be placed in the middle. At the end of the

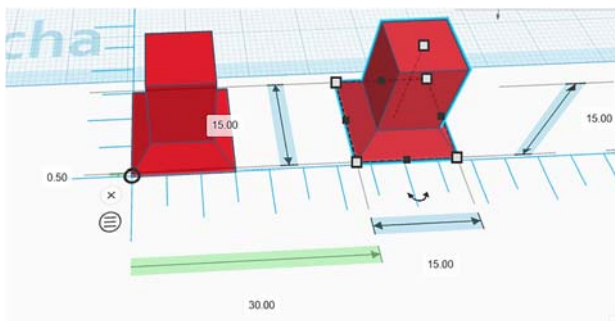
modeling process, we select all parts of the robot and join them together using the **Group** tool.

## 4.5 – Feet placement:

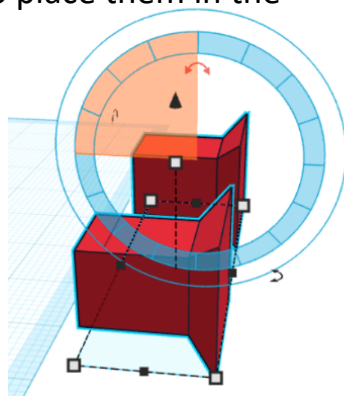
The final step is to attach the legs to the bottom of the robot's body.

**STEP 20:** Using the Ruler tool, which we place in the lower left corner of the robot's shoe, we create the spacing between the legs.

We place the second leg to the right of the left one at a distance of 30 mm from the starting point of the ruler, while checking that the edges of both shoes are aligned with the X axis.



Now we will join the legs (Group tool) and rotate them 90° to the left along the Y axis using the drag handle. Then we will move the legs to the lower part of the torso and use the Align tool to place them in the center.



**TIP:** At the end of modeling, we will combine everything into a single unit using the **Group** tool so that the finished model does not break when moved or exported..

**And the robot is born 😊!**

### Explanatory notes and comments:

LM – left mouse button/left click

RM – right mouse button/right click

Dimensions = XY axis = length x width

(X axis x Y axis)

**\*Note:** In order to illustrate the individual steps and make them easier to understand throughout the process, a supporting instructional video has also been created..

