

3D Design & Printing in Tinkercad

Learning Outcomes

Students would be able to:

- understand the importance of using custom shapes
- use shape generators to insert custom shapes in a design
- customize different features of these shapes to create different objects
- identify the use of code to create new custom shapes
- convert a design into Lego blocks
- give finishing touches to the design
- share and collaborate with others
- use code blocks to create a design

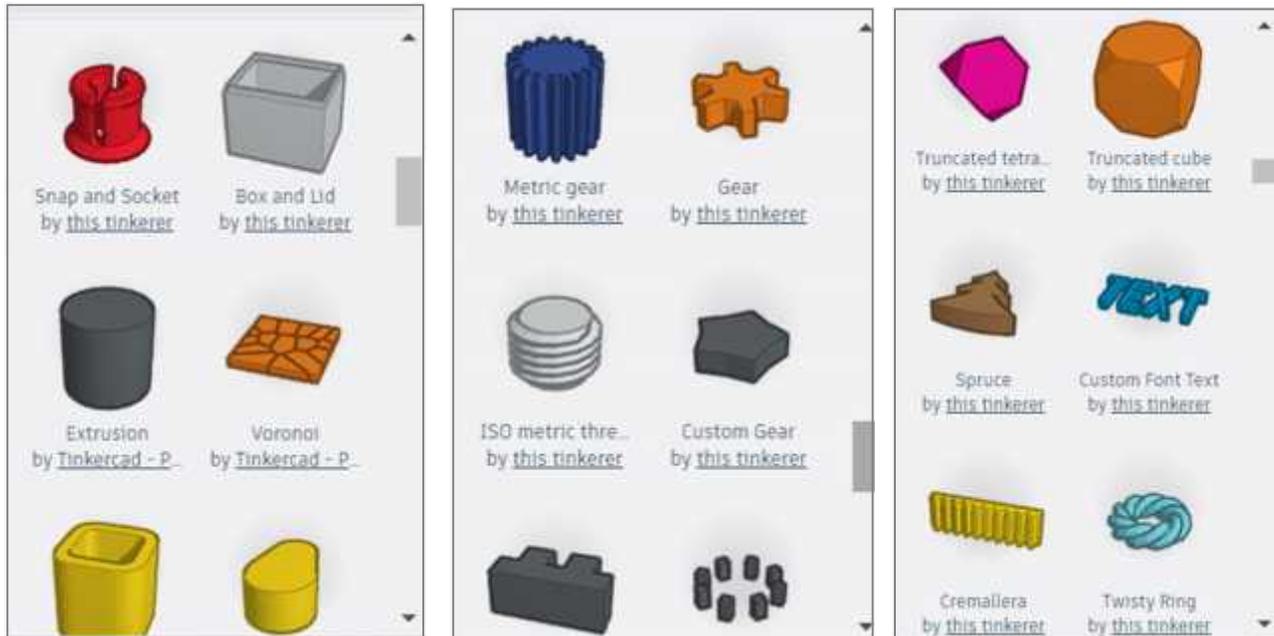
Tinkercad provides us with some basic shapes such as box, cylinder, sphere, etc., that we can use to design complex objects. We can create most other shapes by grouping or cutting away certain parts of the shape using the Hole option. However, sometimes we may need custom shapes that are frequently used for designing complex shapes. This will help us to design our objects quickly without having to create them from scratch.

Shape generators

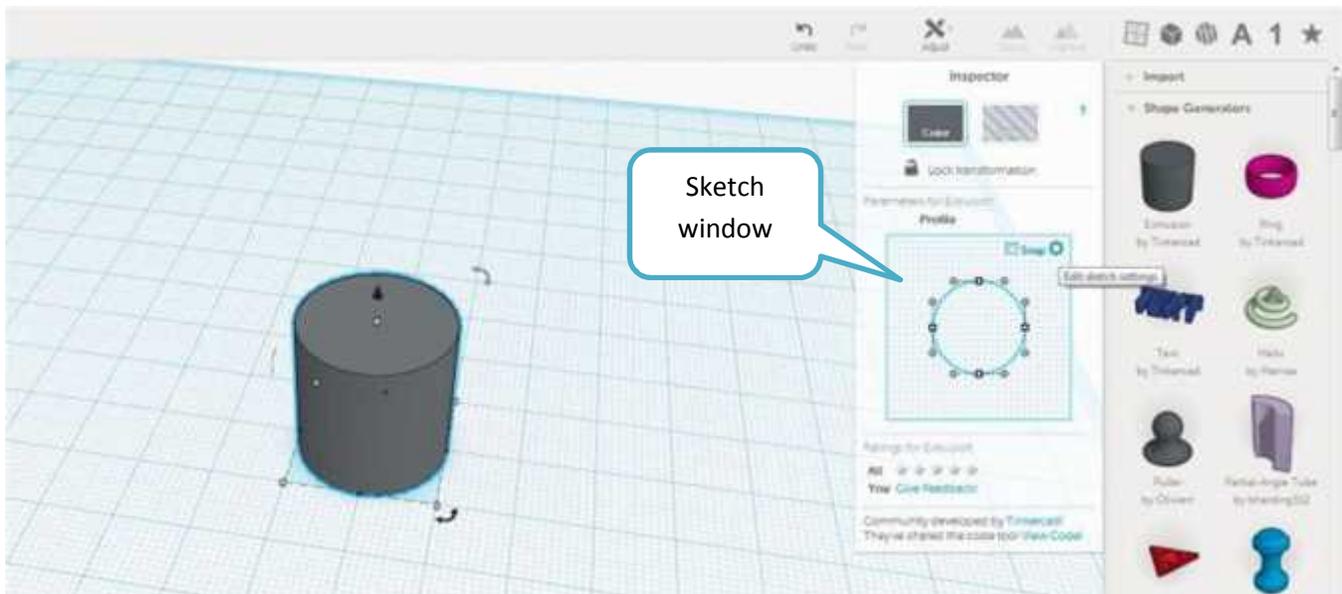
Shape generator is a component in Tinkercad that contains custom shapes that are designed (using Javascript code) and shared by the Tinkercad community. Note that some of the shapes available here may not work and cause problems in your design while others may work very well. You can however use the ones available in Featured section, since they are contributed by Autodesk and therefore they are stable.

These shapes have certain properties that you can change to get different forms. Some examples of shapes here include the Extrusion, Ring, Voronoi, Metric gear, ISO metric thread, Image Generator, etc.

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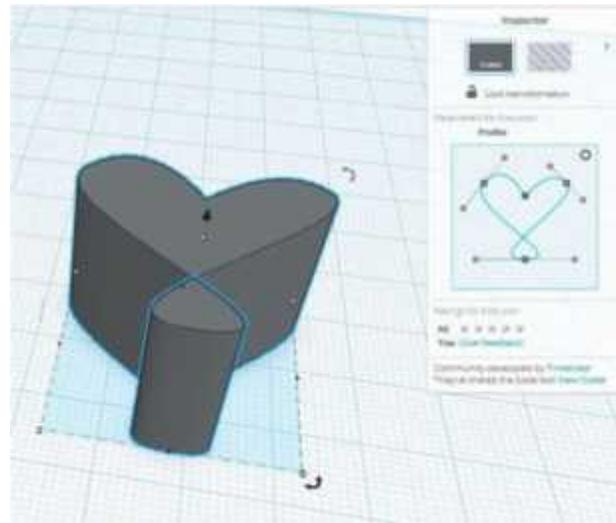
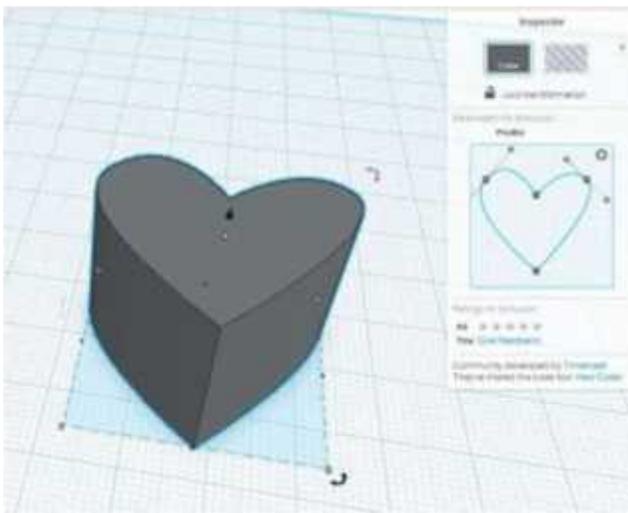
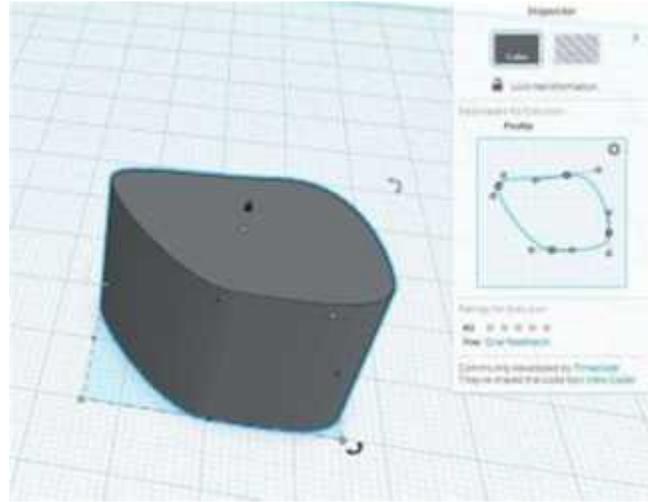
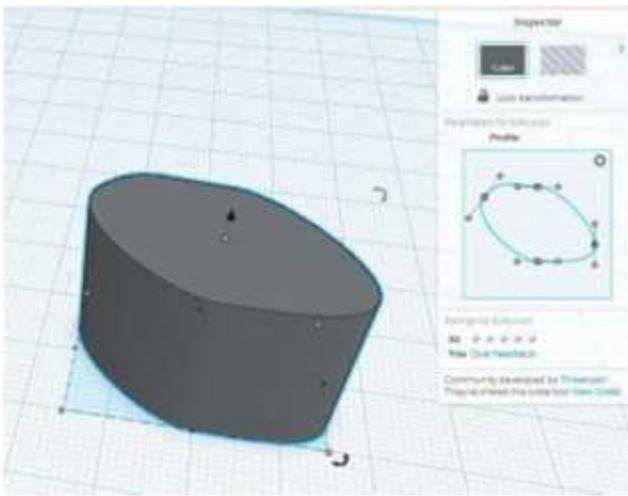
We will start by dragging the Extrude Shape Generator into the canvas and see what we can do with it. The inspector window now shows a sketch window with a grid, which will change your shape in the canvas as you drag the control points. There's a Settings button on the sketch editor that allows you to snap to the grid. Use this tool if you want to be very precise.



The sketches in Extrusion and Ring Shape Generators are created based on curves controlled by Bezier handles. By manipulating the handles, you can create smoother curvatures (moving them away from the center point) or convert the curve into a point if you take these handles all the way into the center point. You can even self-intersect the volume if you keep dragging the handles past the center. The extruded shape will react to each of your changes.

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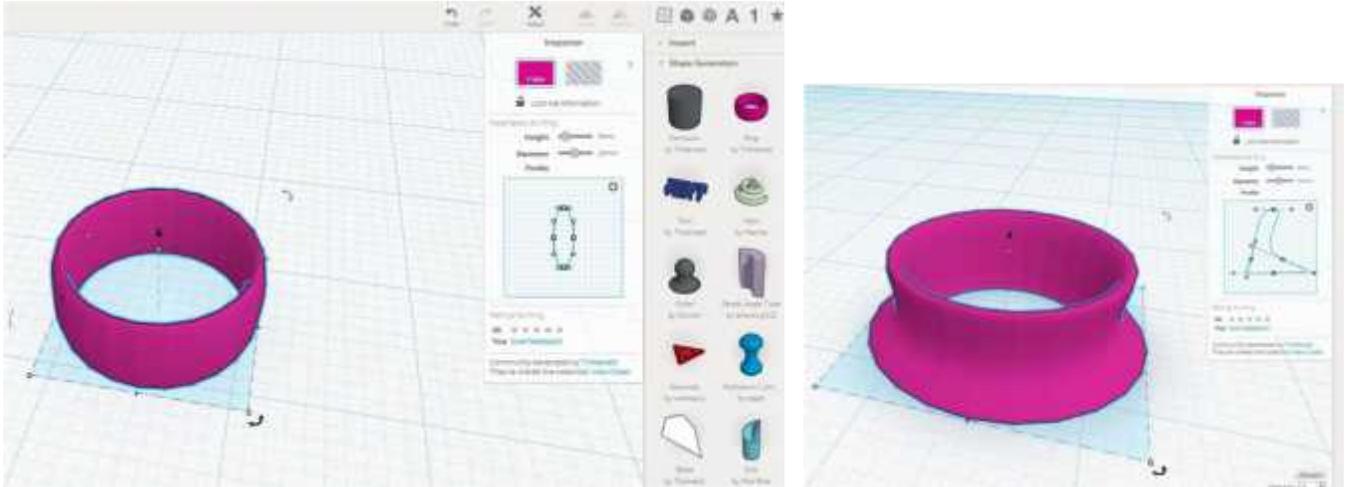
The next four images show all the different scenarios mentioned above.



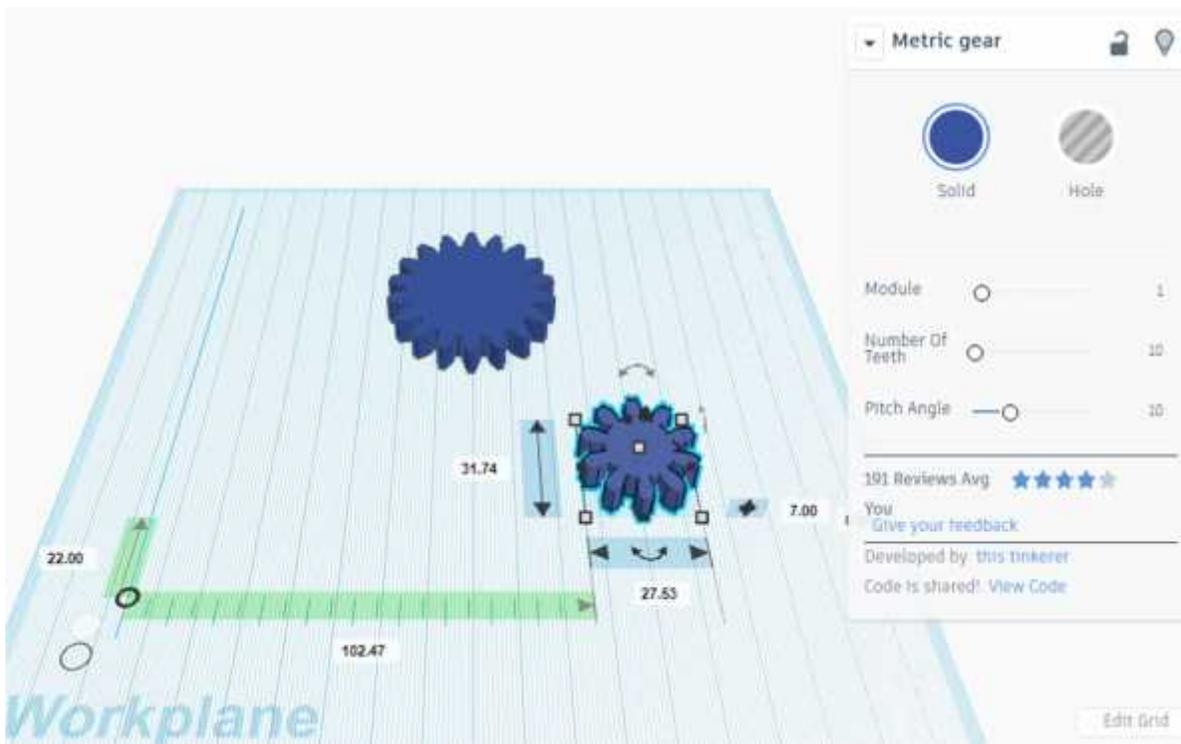
Another interesting Shape Generator is the Ring. It basically shows a sketch with the option to control the Height and Diameter along with the Bezier handles.

Note: You can find the Ring shape in the Basic Shapes in case it is not available in Shape Generator.

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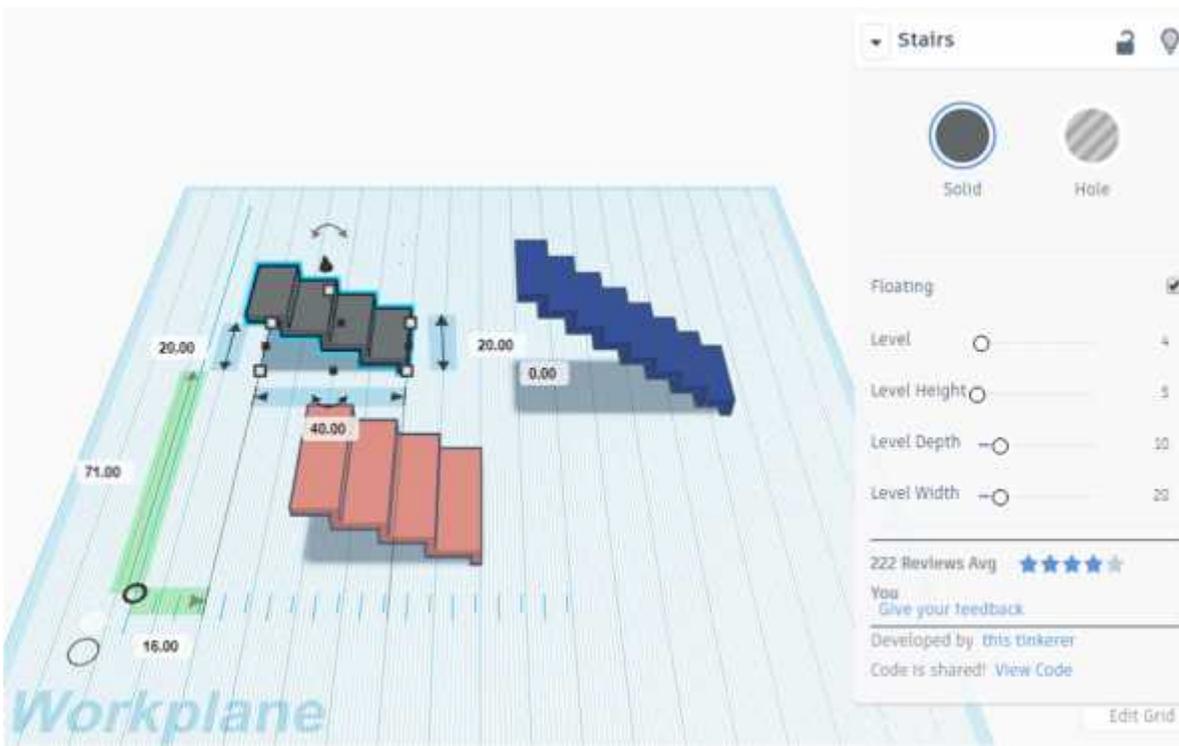
Sometimes, in certain projects, we have a need for gear systems. Designing a gear from scratch would be a tedious task, instead we can use a gear provided in the Shape Generator and customize it to suit our requirement. You can change its size and move it around just as you would with a regular shape. However, a shape from the shape generator has the advantage that each of these has different properties. For example you can change the number of teeth and the shape reacts accordingly. You can also change the pitch of the teeth. This is a very quick way to get up and about creating custom gears for yourself.



Another shape generator is the Stairs. For creating a staircase you could just take a bunch of rectangles and make them into a staircase by grouping them and then resizing. However, the Stairs shape's

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floating palette of options gives you options such as the number of steps, the height, the depth and the width of the stairs. All of these things are quickly customizable for you to use in a project.



Visit the following video links to know more

Shape generators <https://www.youtube.com/watch?v=bbnsAyVhR5s>

Image Generator <https://www.youtube.com/watch?v=ddXqsCkFQAU>

Ring <https://www.youtube.com/watch?v=cuh6EUI-yt4>

Using custom shapes

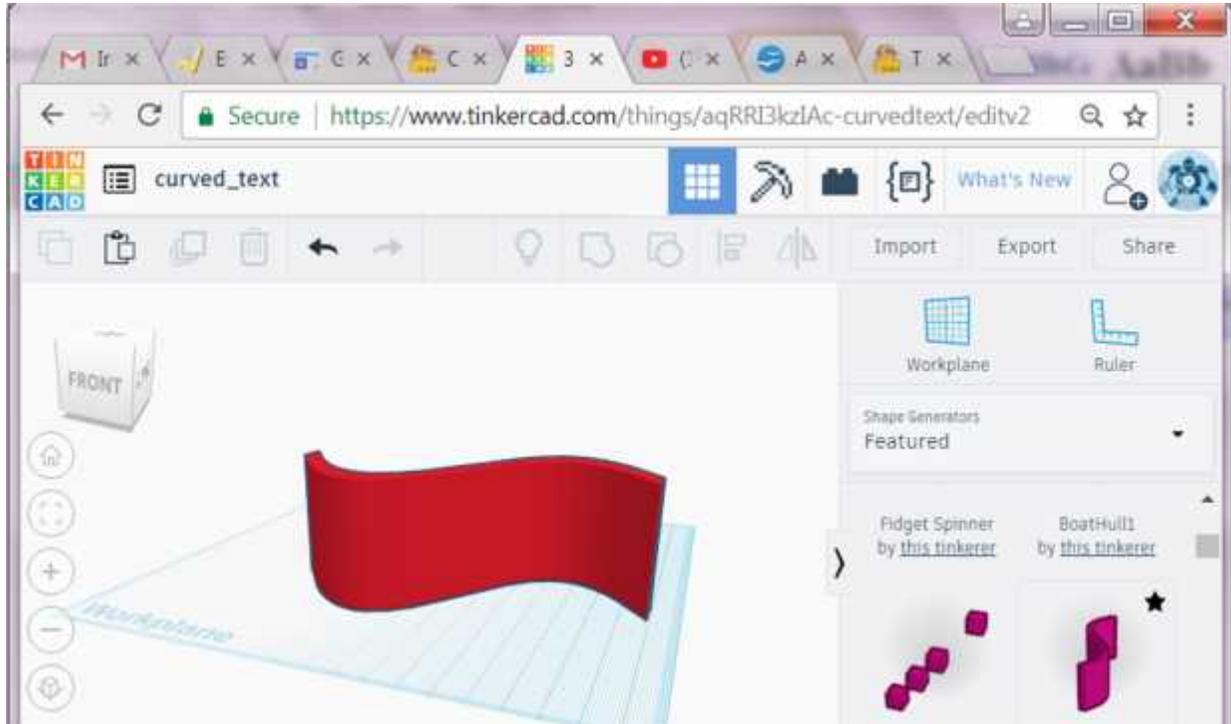
- **Adding text to curved surface**

Let's look at an example of adding text to a curved surface.

The Inspector for Text will show a series of three properties, along with a field for editing the text itself and an option for Height. This is much simpler than adding letters one by one and aligning them. As usual, the text is now an object like any other, so it can be converted into a hole and then subtracted from other objects.

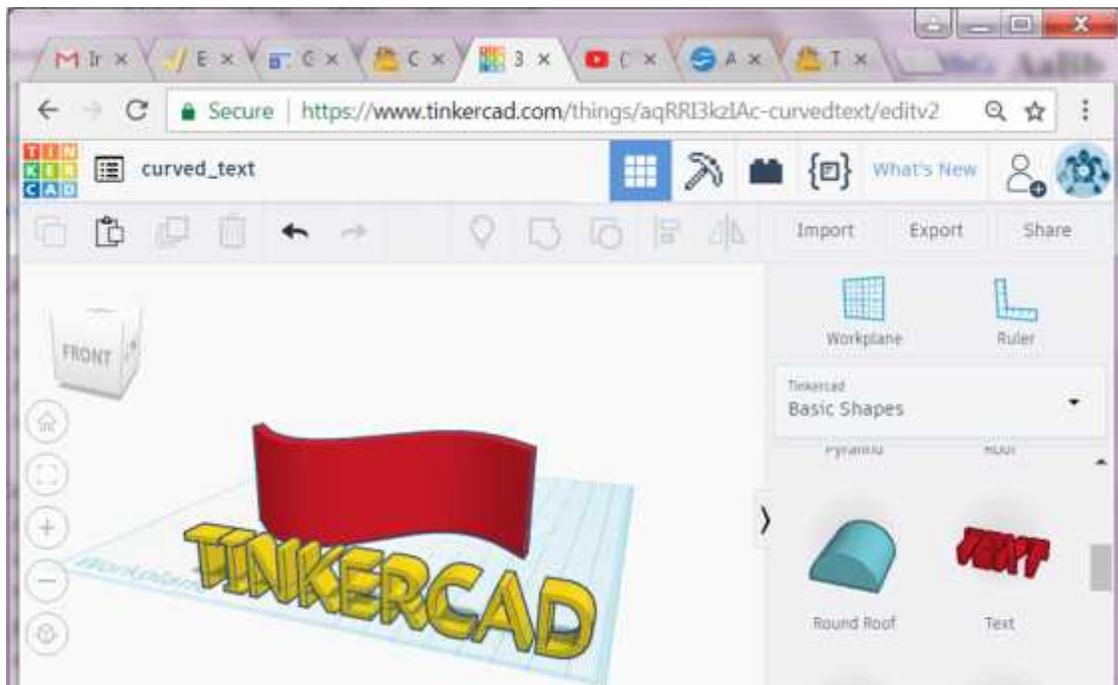
1. First, create the wave shape as shown in the screenshot by using the Extruded Curve or S Wall shape from Shape generators.

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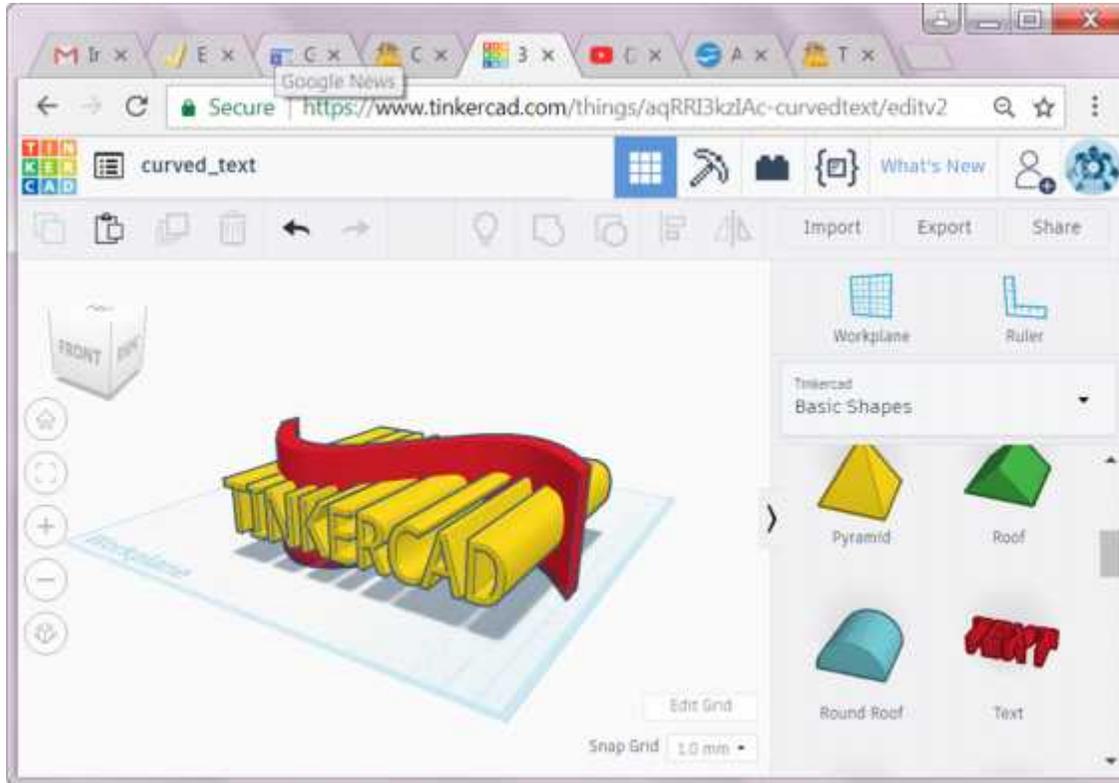
2. Adding Text

Drag the Text shape from right panel and enter your text. Rotate the Text to make it perpendicular to the S-Wall shape. Hold down the Shift-key while you rotate to make this more accurate. Stretch the depth of the Text (or raise the height in the inspector).



Move the Text to cross the wave object, as shown in the screenshot below.

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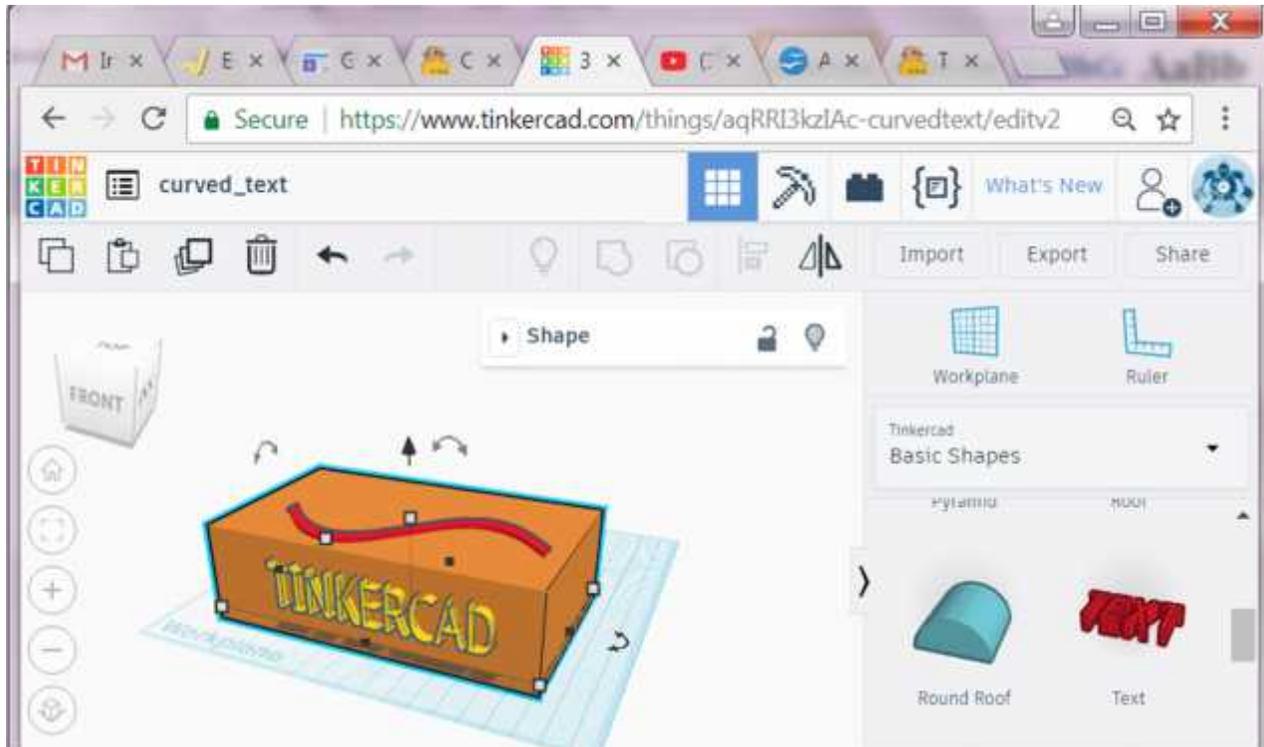


3. Make Hole of the Negative Space.

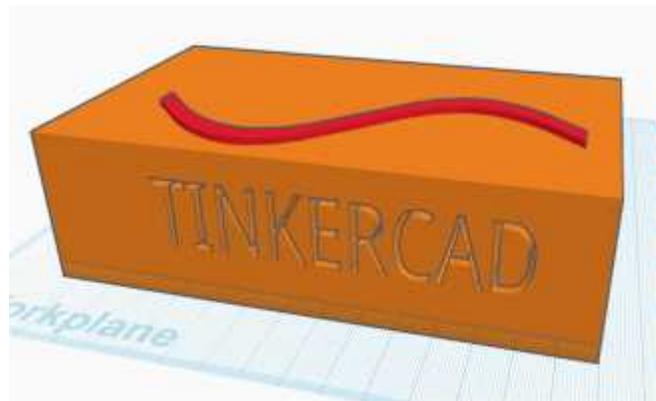
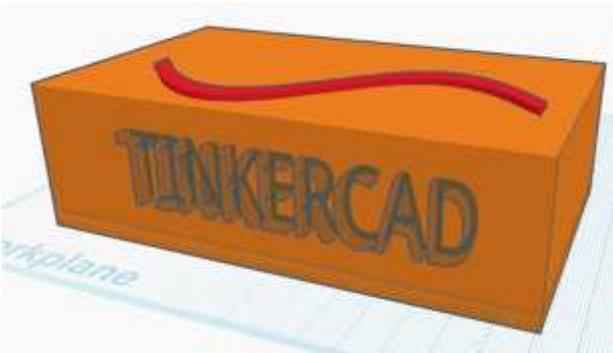
Cover the Wall shape with a Box shape, while letting the Text shape pop out in the front and back. Optionally, let the curved Wall shape stick out to easily select it later. (This might not work for other shapes, so learn to deselect using Shift-key.)

Note: The box is required so that in the final shape the text does not appear as a hole and we should be able to select the text separately

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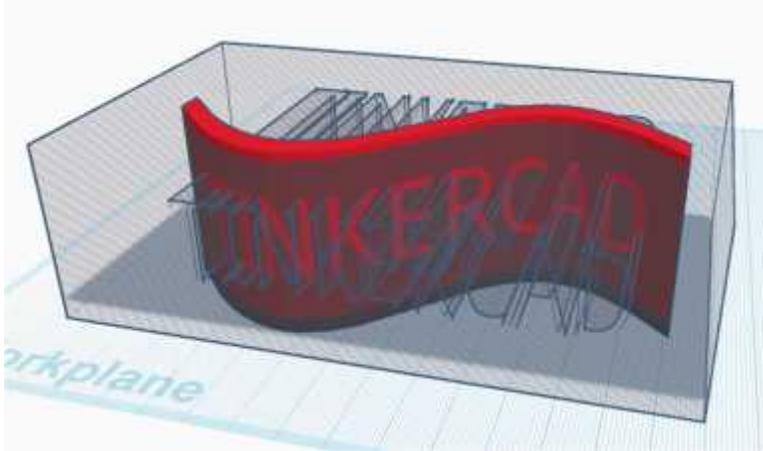


Set the Text as hole. Group Text and Box.



Set new group as hole. Now your design will look like the screenshot below.

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4. Conform Text to Wave Shape

Select the wave shape, use Ctrl + D to duplicate the object in the same location.

If you had the shape stick out, now change the height of its duplicate to less than the grouped Box-and-Text hole.

While the duplicated shape is still selected, hold the Shift-key to additionally select the grouped Box-and-Text.

Now group these two objects. The result should be as shown below.



Use the arrows on your keyboard to move the letters a bit out of the wave and change the color.



Visit <https://www.youtube.com/watch?v=VgVfIfT-Xso> to view a video on the same

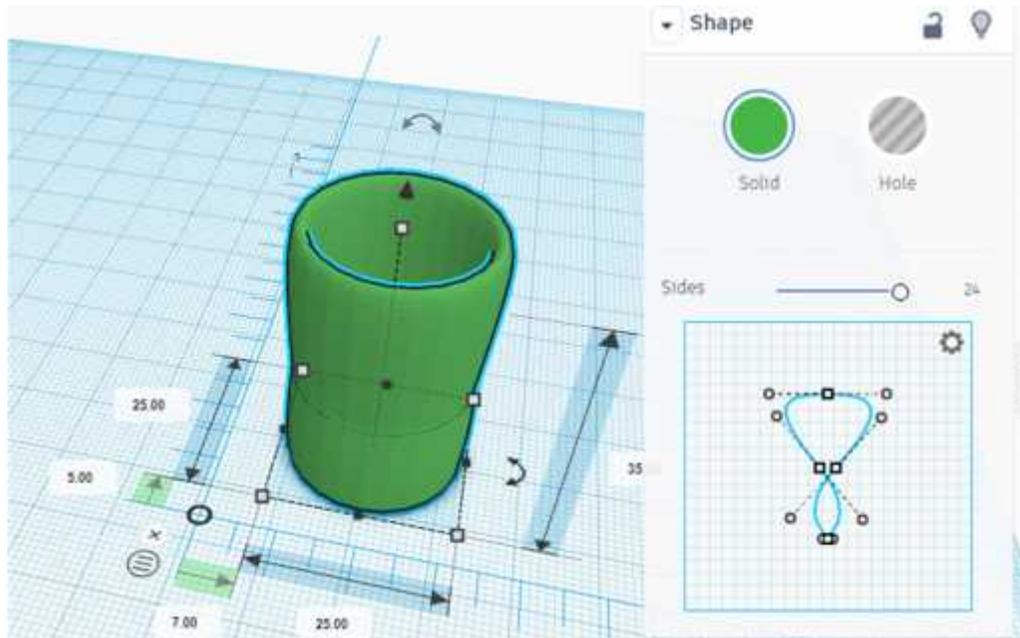
Additional task: Using the same method, create text on the sphere surface.

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- **Using the Voronoi tile to create a candle stand**

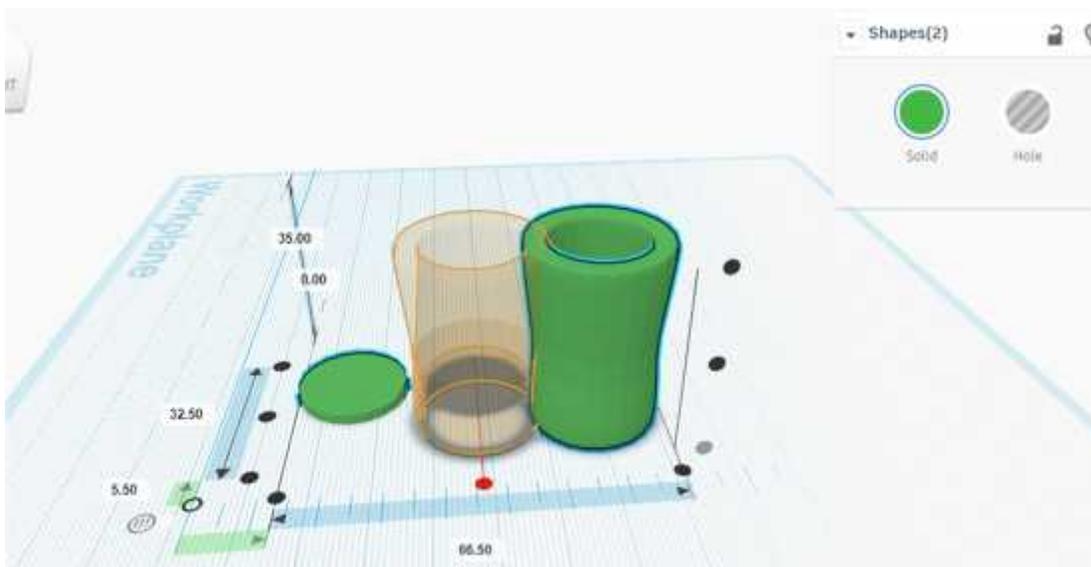
1. Creating the holder using the ring shape

Add a ring shape for the body of the candle stand. Increase the height of the ring as required. Use the bezier handles of the ring shape to give it the required shape as shown in the screenshot shown below.



2. Adding a base for the holder

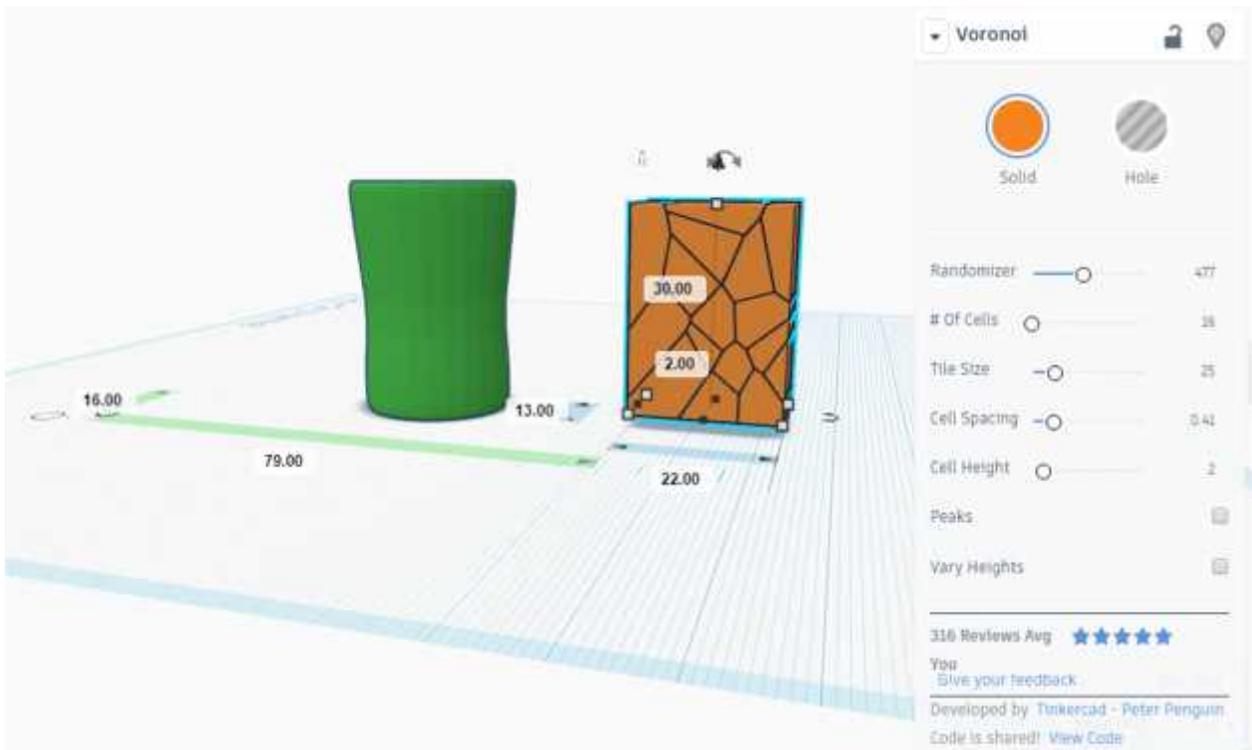
Add a cylinder and reduce its height to 2-3 mm. Make the diameter of the cylinder slightly less than the base of the ring. Then align both objects such that the cylinder forms the base of the candle holder. Group them together to create the holder with a closed base.



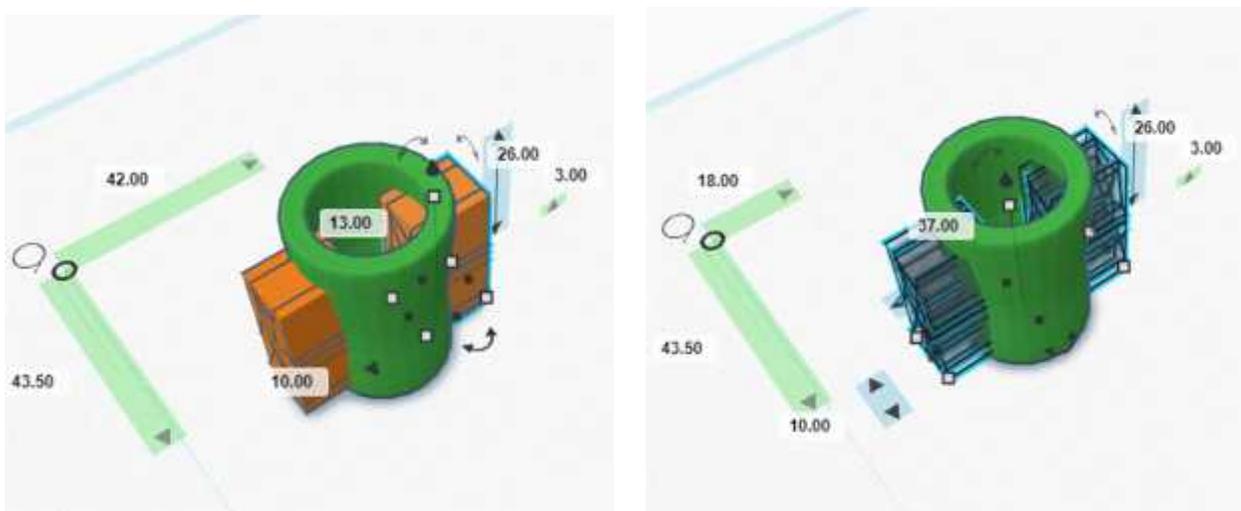
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3. Creating the pattern

Now add a Voronoi shape and adjust its parameters such as no. of tiles, randomness, etc. to get the desired pattern. Rotate it by 90 degrees to get the patterned surface on its sides. Adjust its base dimensions (length and breadth) to half the diameter of the candle holder and its height to slightly less than the height of the holder. This shape will be used to create the pattern on the holder.

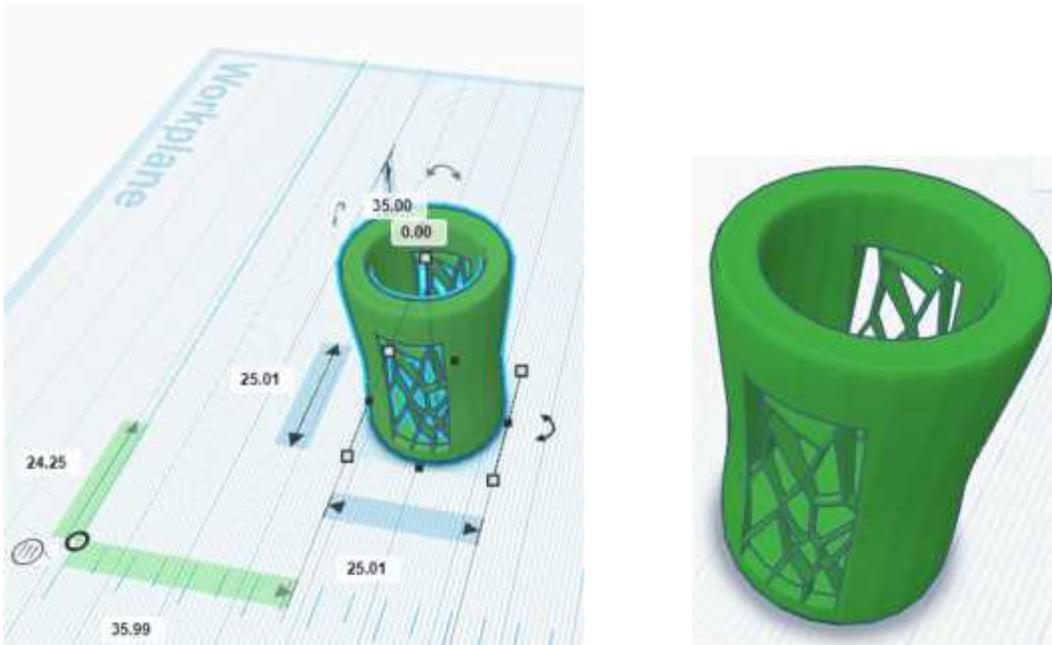


Raise the Voronoi slightly above the workplane, and create a duplicate. Then intersect the two Voronoi shapes with the holder from opposite sides, convert them into holes and group them together to create the pattern.



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The candle holder is ready.



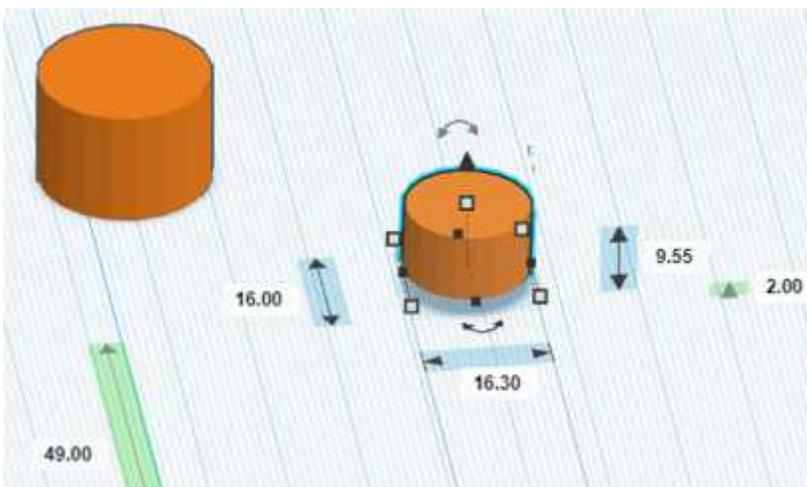
Additional task: Create a candle holder with voronoi pattern on four sides.

- **Creating a container with a screw lid**

Let's create a container with a lid that can screw off and on.

1. Creating the container

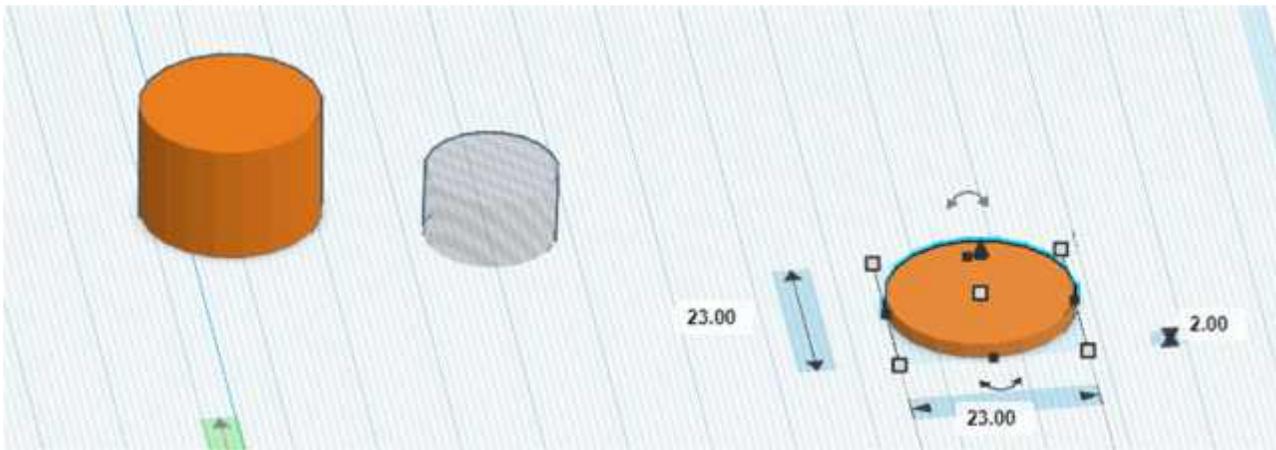
First add a cylinder for the container. Duplicate the cylinder and reduce its diameter and height. This will be used to create the hollow in the container. Convert the smaller cylinder into a hole, raise it slightly above the workplane.



2. Creating the lid

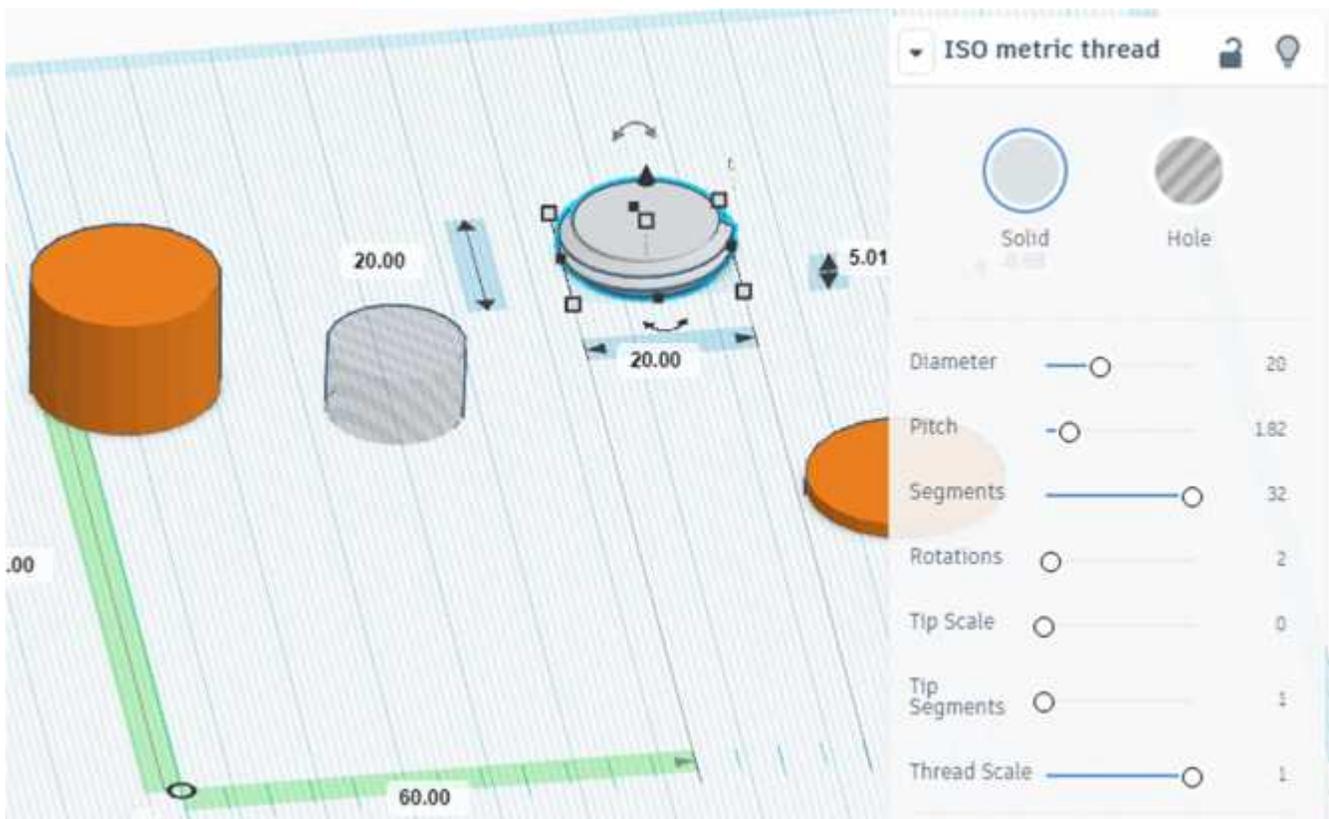
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Create one more cylinder and reduce its height to form the lid. You can increase the diameter of the lid to be slightly more than the container.



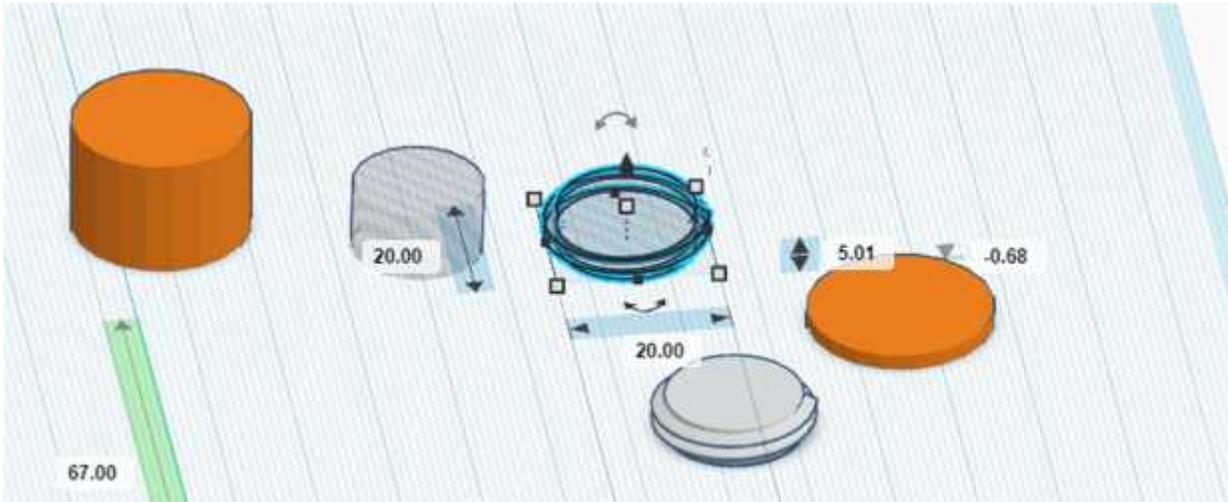
3. Creating the thread for the container

Now add an ISO metric thread from the Shape generator and change its properties and dimensions as shown. Create a duplicate of the same and keep it for the lid.

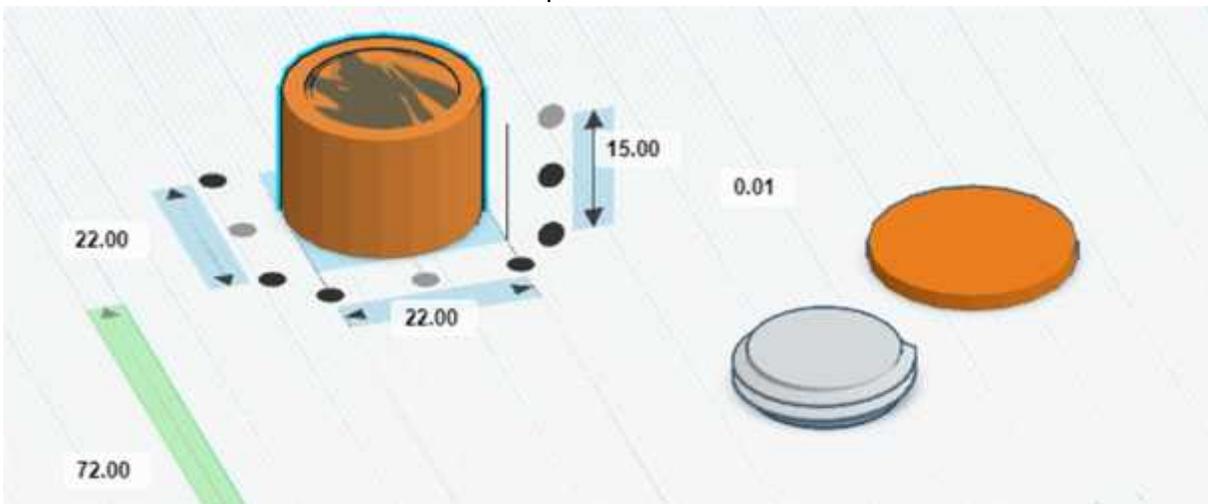


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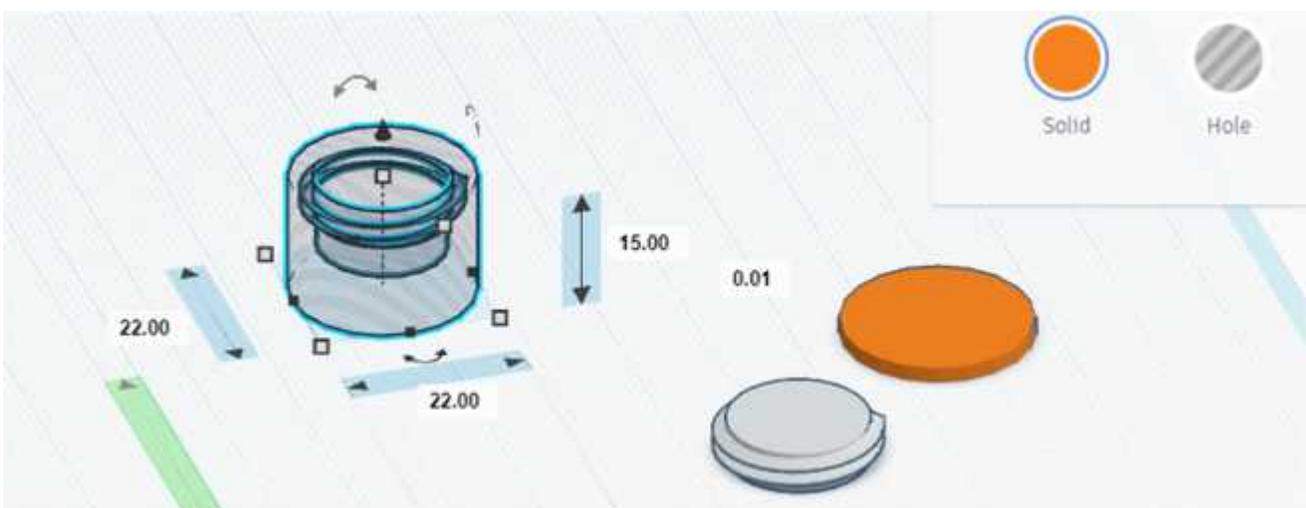
Convert the first screw to a hole and raise it above the container.



Align the solid cylinder, the hole cylinder, and the screw as shown and group them to form the hollow of the container and threads inside the top of the container.



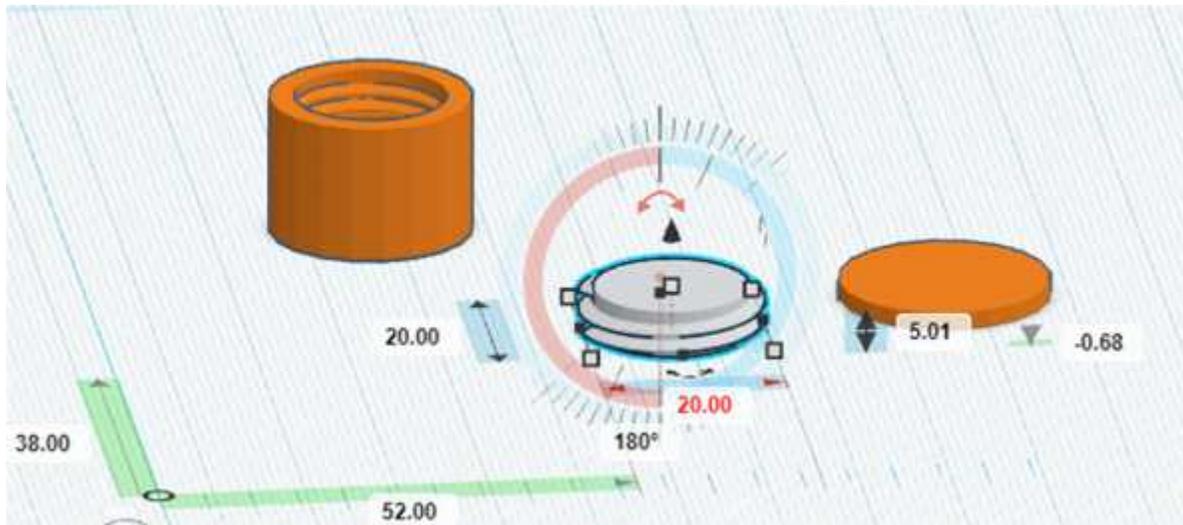
Check that everything is fine inside by temporarily converting the entire object into a hole.



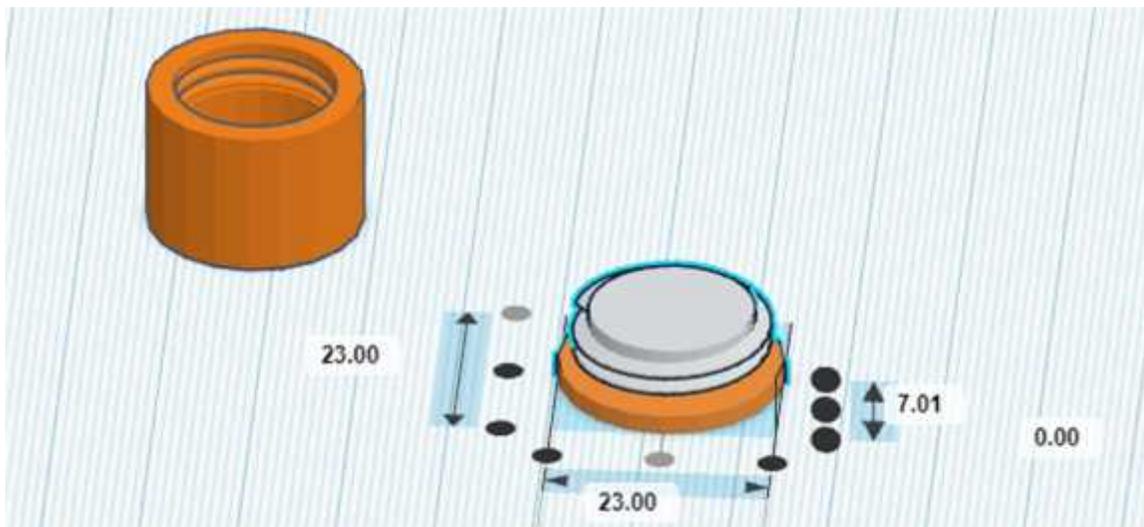
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4. Creating the thread for the lid.

Reduce the diameter of the screw for lid by 1 mm (20x0.95) and rotate it 180 degrees. Then raise it to the level of the top of the lid. Make the ends more curved by increasing the value of Tip Segments. This will keep threads screwing smoothly rather than getting bound up.



Align the screw with the lid as shown and combine both to form the thread for the lid.



The container with a screw lid is ready.



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Print and check whether the lid can be screwed to the container precisely. In case it does not find out the reason for the same and modify the design accordingly.

Visit <https://www.youtube.com/watch?v=FhznDqee3X4> to view the video for the above exercise.

Additional task: Create a flower-shaped lid for the container. Add a keychain holder to the same. Explore the use of other shapes such as Image Generator, Terrain, Twisted Polygon, etc.

Shape generators are a great way to find what you want for your design. If you don't find what you want, try importing a 3D object from Thingiverse! There are literally 1000's of .STL files ready to be imported into your Tinkercad workspace. For example, suppose you designed a small robot but wanted it to stand on a standard size lego block. Find the lego block on Thingiverse, pop on your robot, merge and, you have your new custom lego piece!!

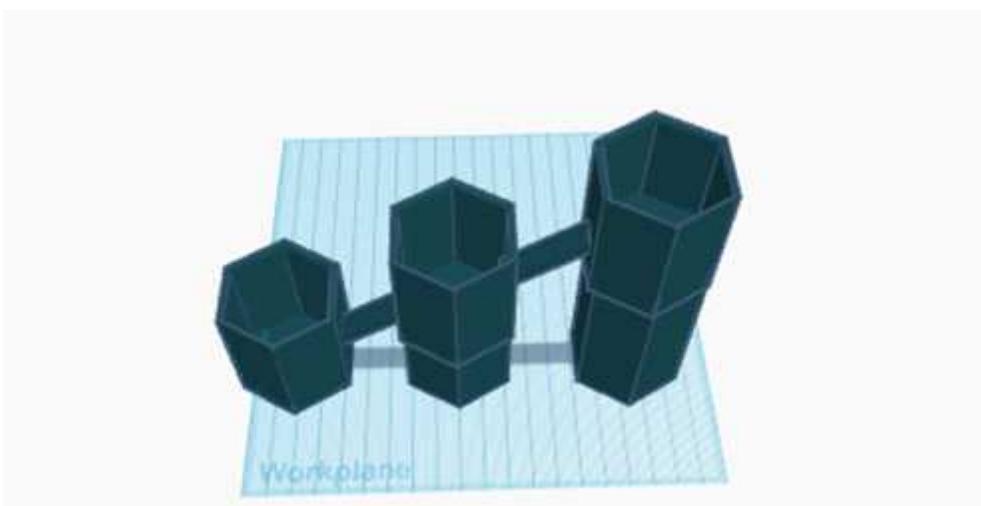
- **Creating new custom shapes**

If you want to learn how any of the Shape Generators were made, you can also click on View Code (as long as the author has allowed others to view code), and this will take you to the Editor. This is where you create a new Shape using Java Script. However, you need to have a good knowledge of Javascript for this.

Converting a design to Lego bricks

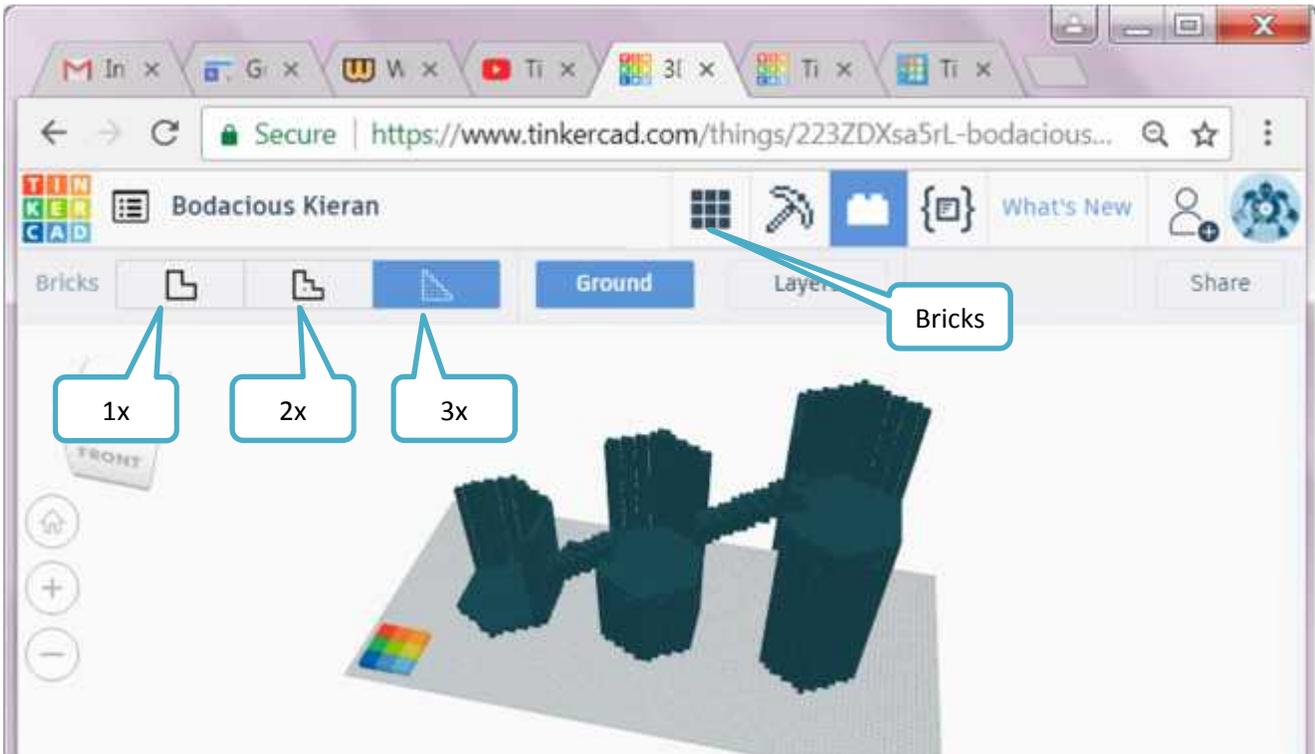
The Tinkercad Brick viewer allows you to convert a design into a brick model that can be then built with lego bricks. You can even view the model layer by layer so that it can be easily built. An option is provided to select 1x, 2x or 3x, where the 1x size creates a simple model requiring less number of bricks while the 3x size creates a complex one requiring a considerably large number of bricks. The 3x model will look more similar to the actual object and will have more details. However, it will require a very large number of bricks to build.

Actual 3D model



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Bricks model in 3x design size



Finishing objects

- **Splitting an object in Tinkercad for printing**

Sometimes the object that you have created may be too large for your print bed and it is not feasible to scale it down. In that case, you can cut the part into 2 or more pieces, print, and glue them together.

To split an object you can use the following technique:

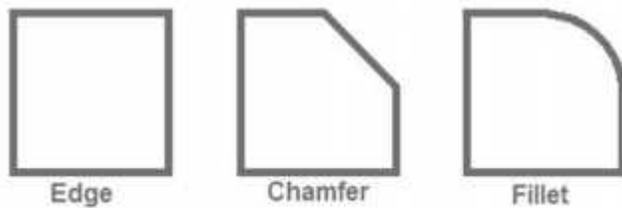
Duplicate the item. In one item, cut off a part you want. Then, duplicate what's left as a hole. Use that on its proper position on the other model. Repeat for more. Also, clicking "edit grid" will help you to stay within the parameters of the printer you want. If little scratches of the piece that was cut with the holed duplicate, just use a regular shape from the menu and hole that away.

View video on <https://www.youtube.com/watch?v=3Zwtr115qHU> for splitting an object into two parts.

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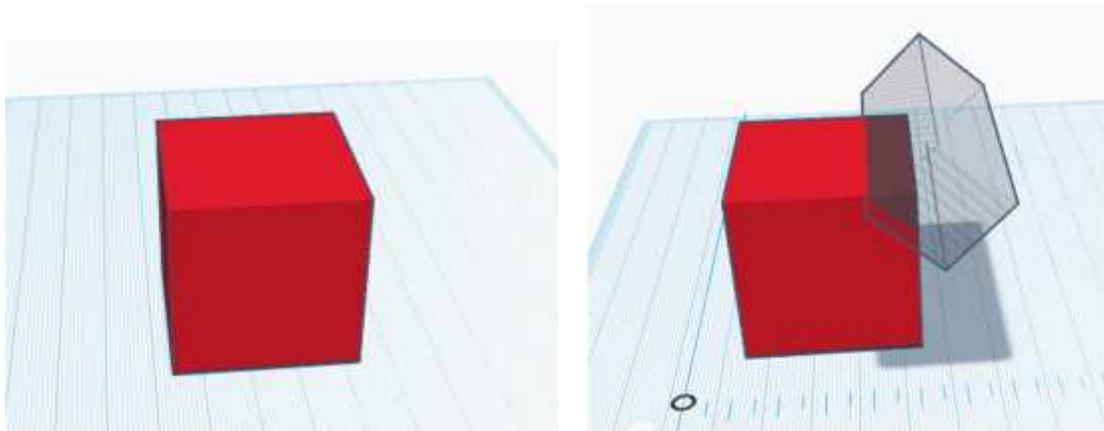
- **Chamfers & Fillets**

In design and machining, a chamfer is a sloped or angled corner or edge, and a fillet is a rounded corner or edge. These edges can be located on either the interior or the exterior of a part.

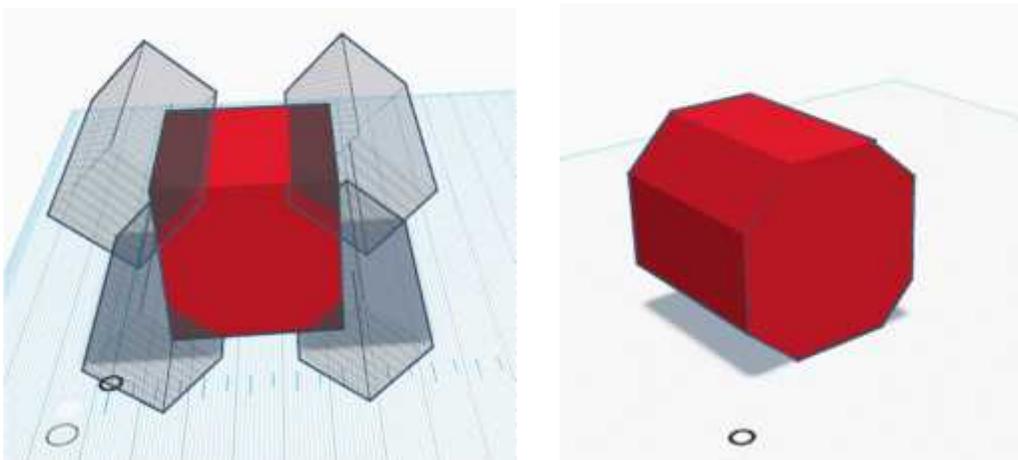


Let us see how we can chamfer the edges of a box.

Add a box shape. Create a Hole box. Raise and change its angle. Intersect it along with one edge of the box.



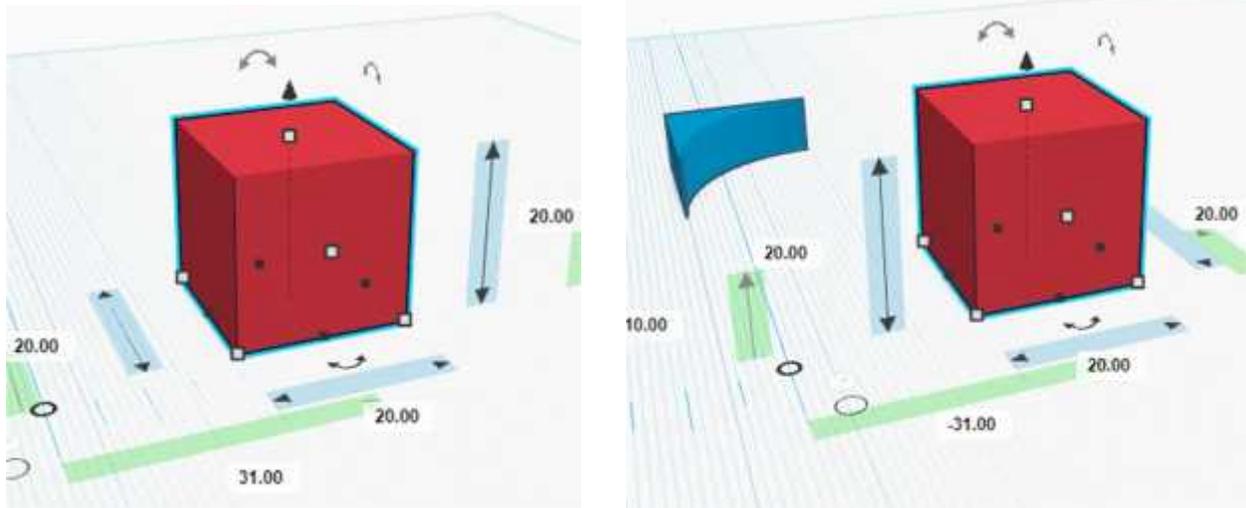
Repeat for other edges as required. Group all objects. The edges that intersect with the hole boxes will be cut away. Similarly we can chamfer a corner.



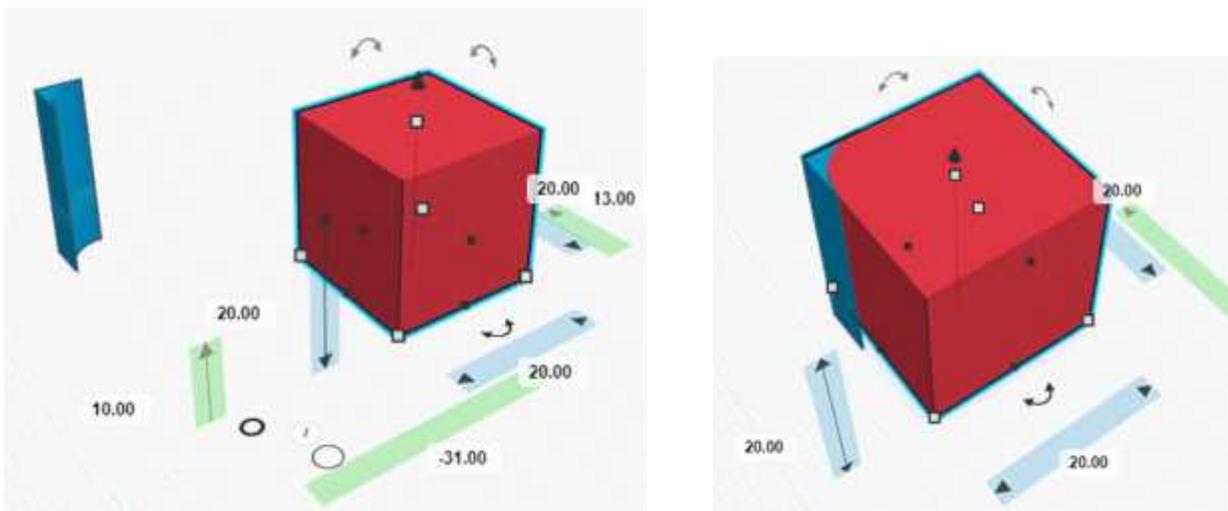
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Follow the given steps used to fillet an edge.

Add a box. Add a MetaFillet shape. (You can also create this shape by grouping a box with a hole cylinder) Make the radius of curvature to the desired value.

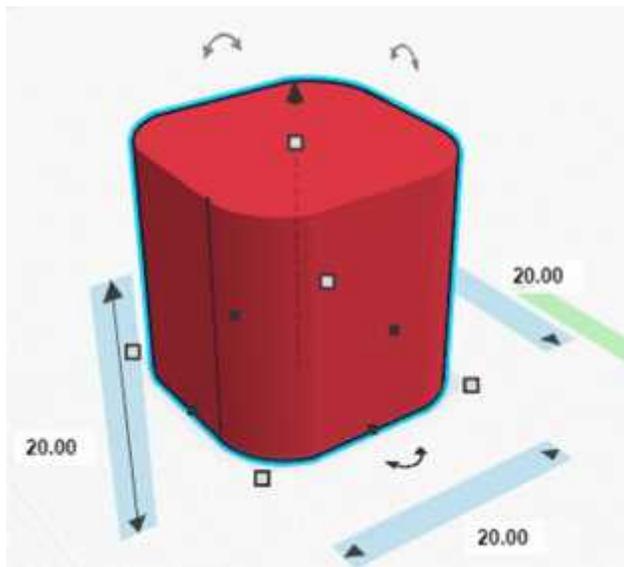
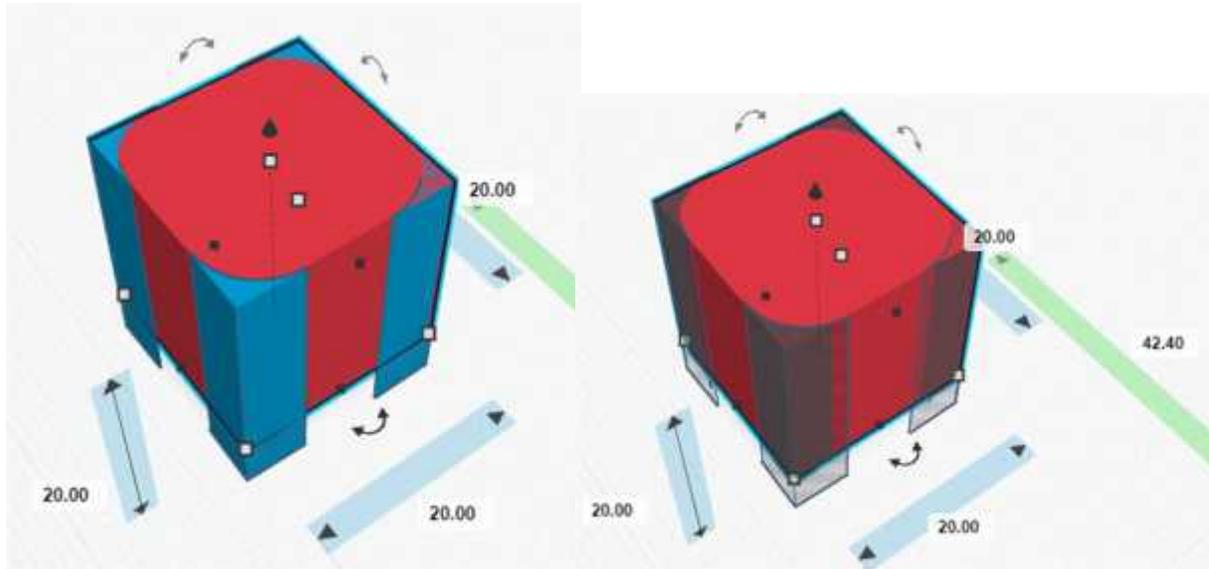


Adjust the height of MetaFillet to slightly more than the box. Raise it and align with the edge of the box as shown.



Duplicate this MetaFillet and rotate or flip and align it with the next edge. Repeat this for the remaining edges. Select all four MetaFillet and convert them to Hole. Group all objects to get the final shape.

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View the following videos to learn more.

<https://www.youtube.com/watch?v=zv5GVVxx4QU>

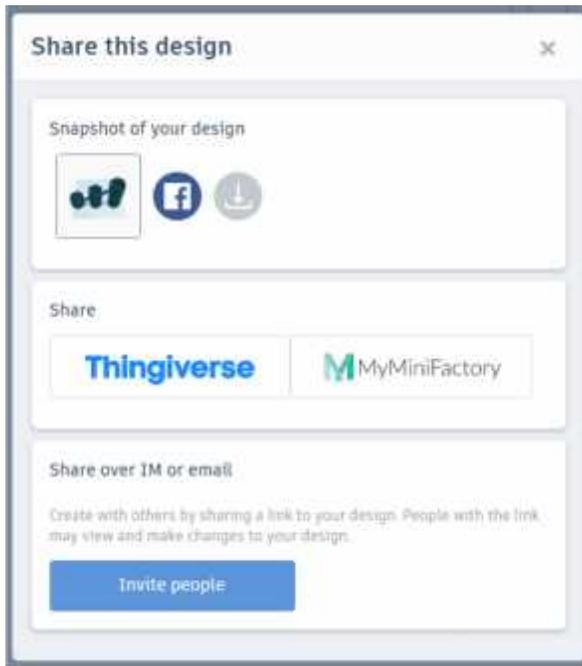
<https://www.youtube.com/watch?v=J-6X6in6Las>

Live collaboration and editing

Tinkercad provides the Sharing feature through which a group of people can work on the same design in real time thus allowing collaboration projects. Teachers can also be a part of this and help out without having to stand and watch over the students working on their computers. A change made by any user will be reflected in the original design and all users will be able to view it.

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In order to collaborate, the creator of the original design has to share a link with those they want to collaborate with. Once the link is received and clicked on, they too can work on the same project.

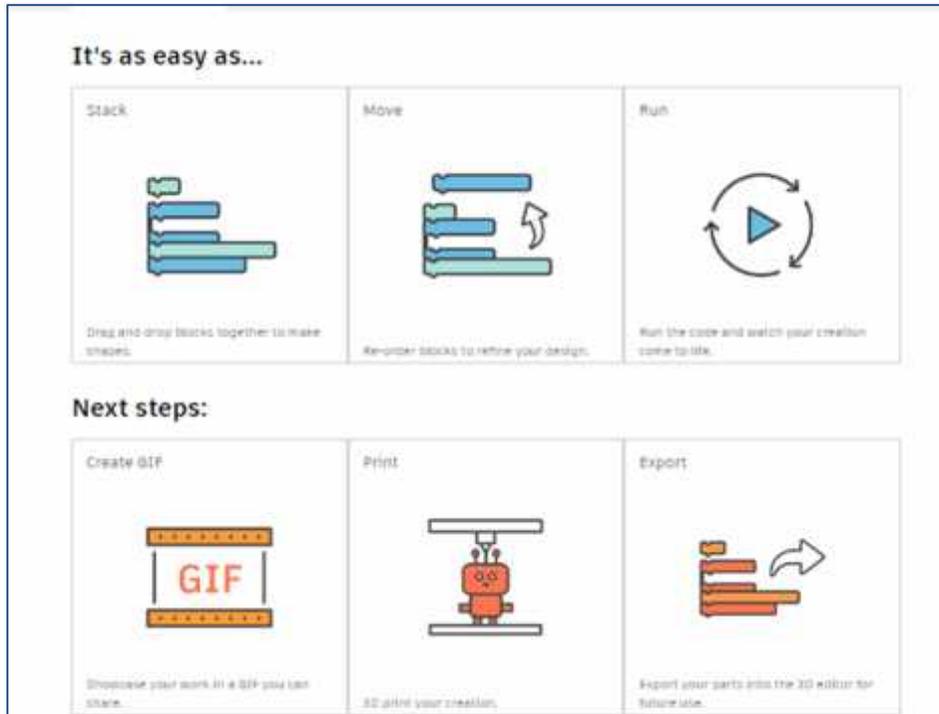


Codeblocks

Codeblocks is a new beta addition to Tinkercad. It allows the creation of 3D designs using visual programming. Codeblocks allows the creation and use of variables. Values of variables can be changed to easily create designs of different sizes.

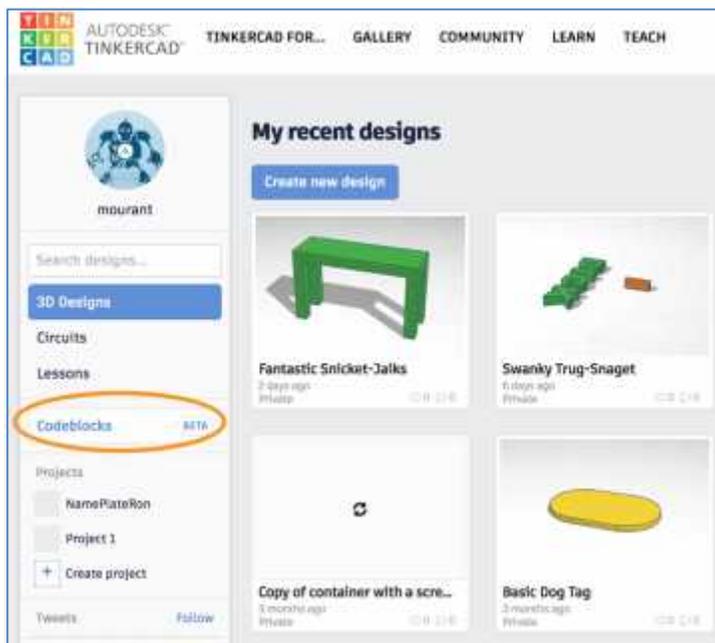
Steps to create 3D designs using Codeblocks

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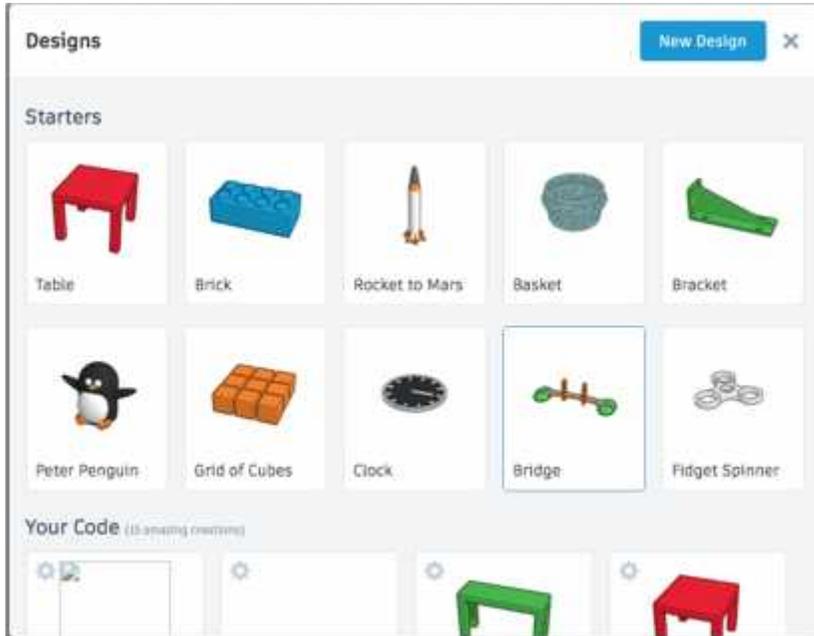
Creating designs using Codeblocks

- Click on the Codeblocks button. Tinkercad presents a dialog box (you can scroll vertically).



- There are two sections in the dialog box. **Starters** are examples of 3-D designs created using codeblocks. These are useful for learning how to use codeblocks. **Your Code** shows designs that you created or modified using codeblocks.
- Select an existing design from the Starter or create your own new design.

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Creating Tea Light holder

Let's see an example of using code blocks to create a Tea Light holder:

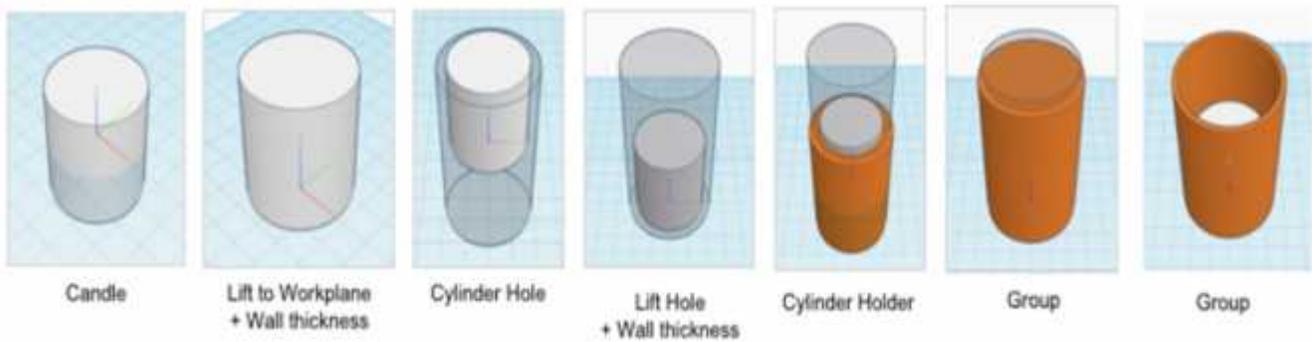
- Add the first code given below to create a new solid cylinder 'candle' of radius 18.5 and height 40. The X-axis (Width) is red, the Y-axis (Length) is green, and the Z-axis (Height) is blue.
- When an object added to the workplane using code blocks, its centre is placed at X=0, Y=0 and Z=0. Therefore, we need to lift it to the workplane. However, to keep a base wall thickness, lift it slightly above the workplane keeping a base thickness of $22 - 18.5 = 3.5\text{mm}$



Naming objects is important so that it can be referred to later in another code. All named objects can be found in the list of blue variables blocks at the bottom of the shapes panel.

- Add the second code to create a hollow cylinder with radius greater than the 'candle' (23mm) and twice its height (80mm) to create the hollow space between the 'holder' and 'candle'.
- Finally create a solid cylinder of radius 25mm and height 76mm and lift it the work plane. Then group all three objects to create the final candle holder.

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Creating Patterns

Now we need to create a pattern on the wall of the holder. The code below shows how we can create a shape 'quatrefoil' used to create a pattern. You can create any other shape for generating the pattern of your choice.

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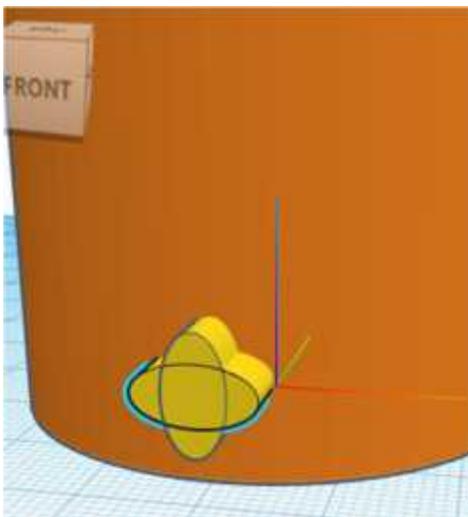


The codeblocks editor (center column) allows a group of codeblocks to be dragged to the trash can (at the bottom-right).
A new codeblock may be added at any place in the list of codeblocks. You create a place for it by dragging down (unsnapping) at the point of insertion.

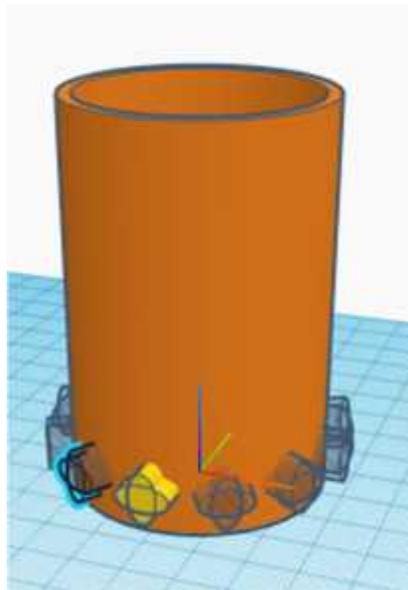
We can now create a circular pattern of 'quatrefoil' shape around the wall of the holder using the following code. Remember to convert the copy of 'quatrefoil' to a hole. One full circle is 360 degrees, therefore we can have 12 quatrefoils each copy is rotated by 30 degrees from the previous copy. Using this calculation, If we wish to have 10 quatrefoils, we should use the value of angle as 36 degrees in the code.

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```
Create New Object  CirPattern ▾  
// create a variable angle to store the value of the angle by which the quatrefoil will be rotated  
Create Variable  angle ▾ 30  
// Start a loop that will repeat 12 times  
Repeat 12 Times  
// Add a copy of quatrefoil in the same position as the original one  
Add Copy of Object  quatrefoil  
// Rotate it by 30 degrees from the previous position around the z axis around the pivot point set at the centre of the workplane  
Rotate around  Axis z ▾ by angle Degrees from Pivot  X: 0 Y: 0 Z: 0  
// change the value of angle by 30 so that next time in the loop the copy of quatrefoil rotates an additional 30 degrees from the original position  
Change angle ▾ by 30  
// Delete the original quatrefoil  
Delete Object  quatrefoil
```



quatrefoil

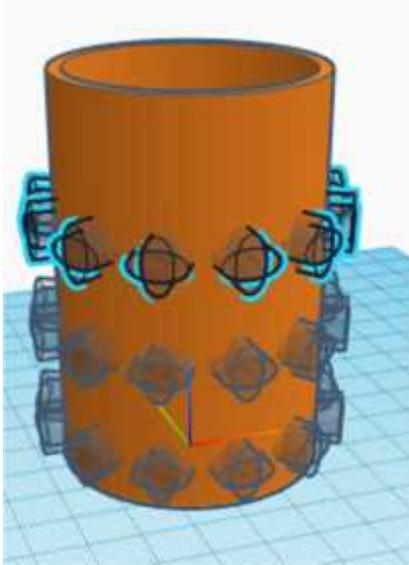
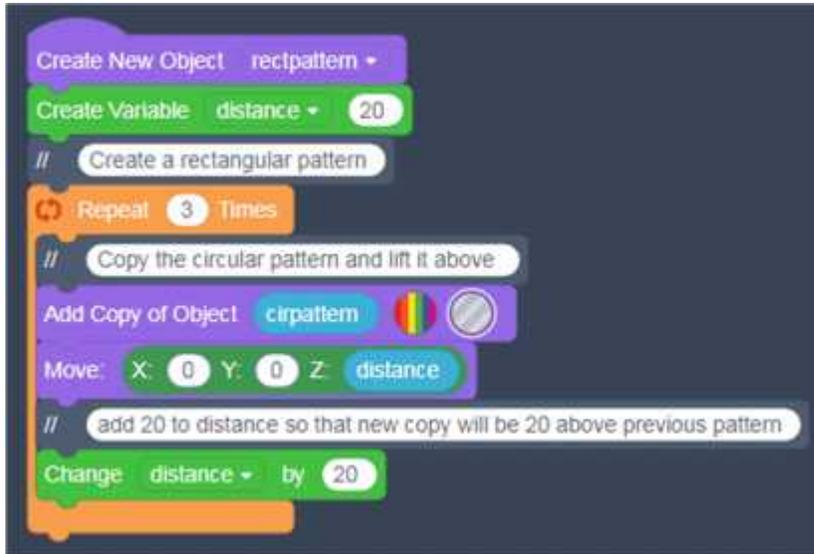


circular pattern

Do not forget to delete the original quatrefoil shape used to generate the circular pattern.

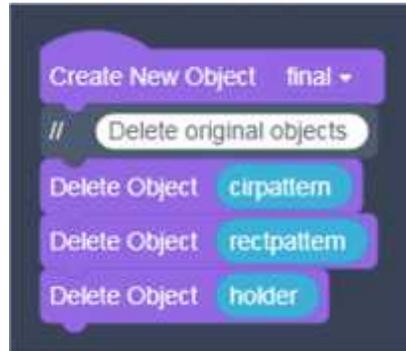
This circular pattern can now be used to create a rectangular pattern as shown using the following code.

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Finally create the 'tealight' object by adding copies of 'cirpattern', 'rectpattern' and 'holder' and grouping them. The original objects should be deleted

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We can also make GIF recordings of the Code-CAD creations. This can be done inside the Tinkercad editor by hitting the Share button and then choosing to "Save Gif" in the next screen. Make sure to run it first in the editor.

Another example of codeblocks for creating a table is shown below. It uses calculations to create a table whose width, length and table top thickness can be customized.

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```
Create New Object table1 -
// variables to store length, width, height, legsize and thickness of table top
Create Variable Xwidth - 35
Create Variable Ylength - 35
Create Variable Zheight - 15
Create Variable legsize - 2
Create Variable tabletopheight - 3
// Add a box, it is centred at X=0, Y=0 and Z=0.
Add [Box] W Xwidth L Ylength H Zheight edge 0 Edge Steps 10
// lift it above the workplane to allow for table top thickness
Move: X: 0 Y: 0 Z: tabletopheight
// Add one hollow box with width= width-legsize to take away inside of table in x direction
Add [Hollow Box] W Xwidth - - legsize - - 2 L Ylength H Zheight edge 0 Edge Steps 10
// Add another hollow box with length=length-legsize to take away inside of table in y direction
Add [Hollow Box] W Xwidth L Ylength - - legsize - - 2 H Zheight edge 0 Edge Steps 10
// group all to create the table
Create Group [Group]
// lift the table to make it sit on the workplane
Move: X: 0 Y: 0 Z: Zheight / - 2 - - tabletopheight
```

The above code shows the use of variables and operators to calculate the measurements.

Creating a table with a different size top is easy when using Codeblocks. Simply change the values of the variables that represent the width and height.

Exercise Questions

Q.1. Fill in the blanks

- The sketches in Extrusion and Ring Shape Generators are created based on curves that can be controlled by _____ handles.
- Number of teeth and Pitch angle are properties of the _____ shape.
- You can create new custom shapes using the _____ programming language.
- To create a Voronoi pattern through a solid object, you need to cross it with the object and make the Voronoi tile into a _____.
- In design and machining, a rounded corner or edge of an object is called a _____.

