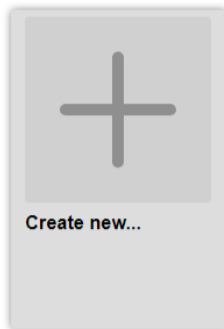


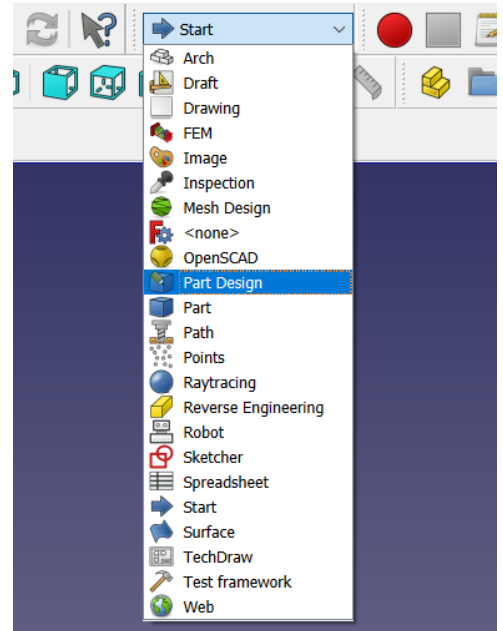
Modeling a LEGO brick with FreeCad

Here we will use the "Part Design" workshop to define the part. This workshop will allow to design and dimension completely in 3D a brick then to generate the file intended for the 3D printer (extension ".stl"). This same file could also be used to drive a numerical control machine (CNC).

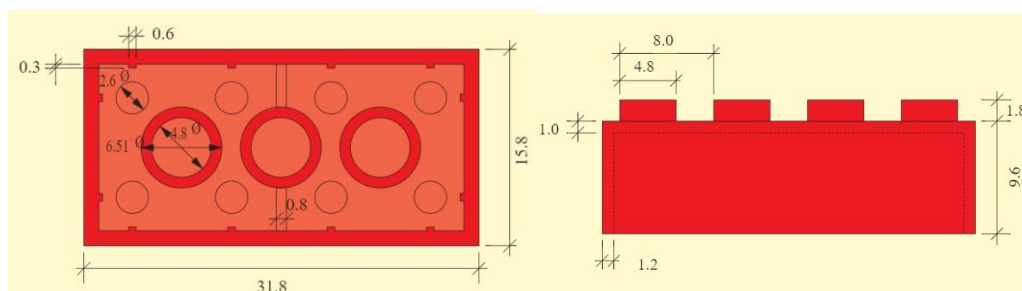
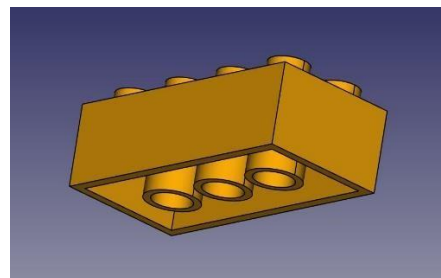


Run FreeCad and create a new document.

Then in the upper scroll-down menu select "Part Design".



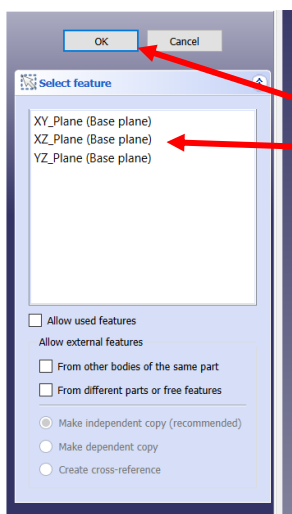
To illustrate how the Part Design workshop works, let's create this well-known Lego brick. We will start with the standard 8x2 brick... All dimensions of this piece can be found below. Feel free to come back to this page if you are unsure.



All 3D objects are based on a 2D drawing called "sketch". The great strength of FreeCAD is that it allows to apply constraints on each part of the drawing. This is quite convenient because if you want to change one of these constraints later it will automatically adapt the drawing.

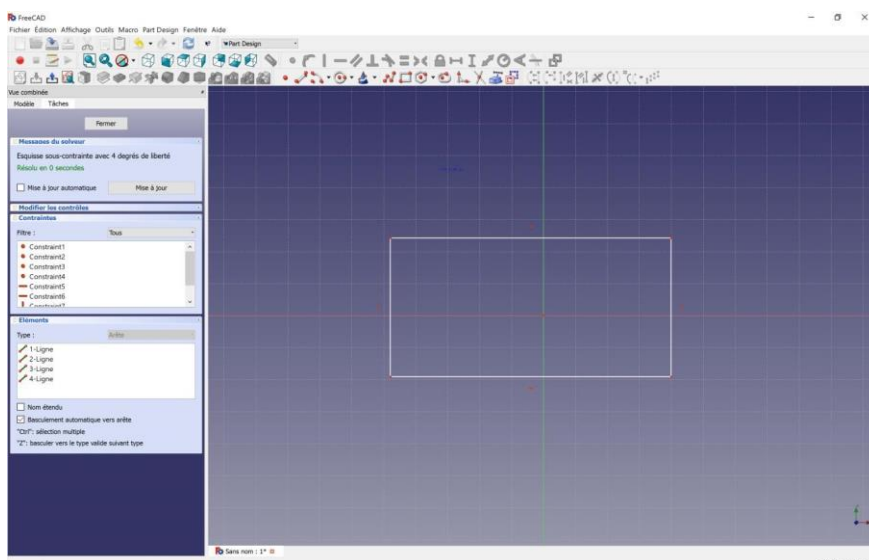
At first the interface of the software and the number of parameters are a bit confusing. Don't panic! After this workshop you should have mastered all the basic functions of the software.

- Click on the New Sketch button (📄). A dialog box will appear asking where you want to build your sketch, choose the XY plane, which is the "ground" plane. The sketch will be created and will immediately be changed to edit mode, and the view will be oriented to look at your sketch according to the normal to the working plane.

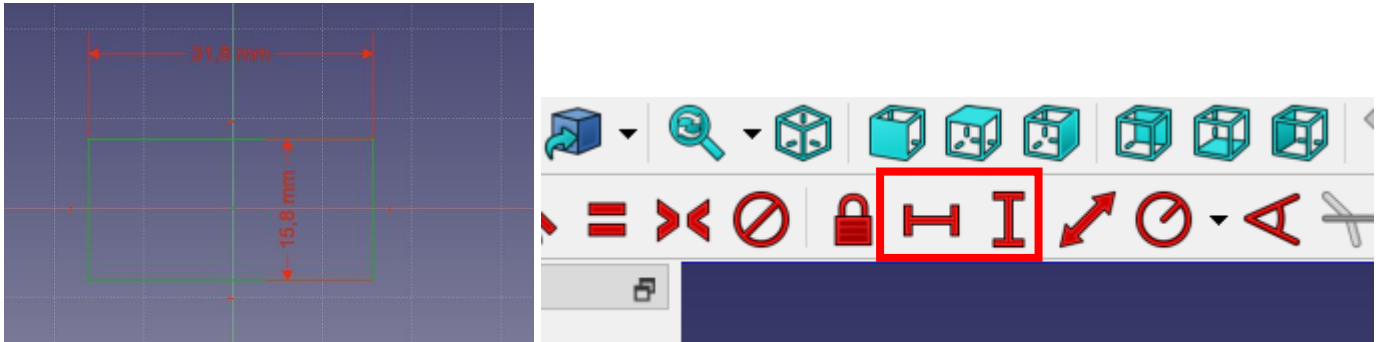


Select « XY_Plane » and then click “OK”

- Now we can draw a rectangle, by selecting the rectangle tool (📐) and clicking two vertices diagonally. You can place the two points anywhere, as their correct location will be defined in the next step.

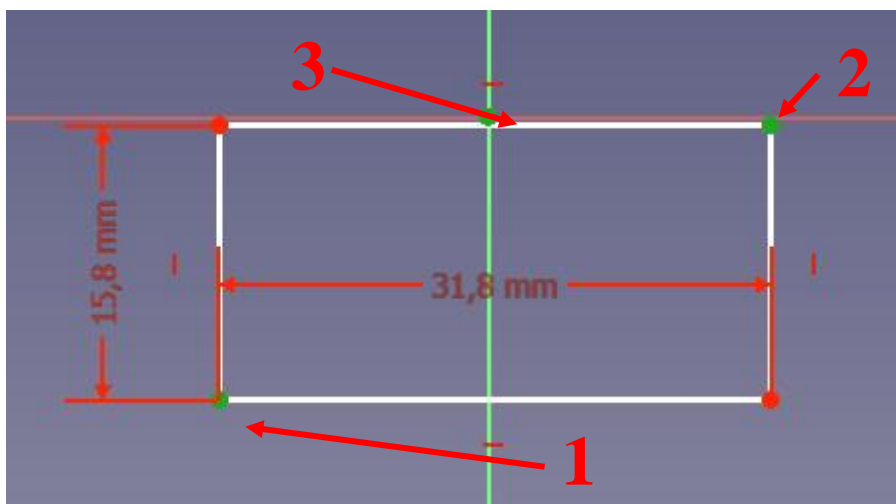


- We will now add three more constraints:
 - Select one of the vertical segments (it becomes green) and add a vertical distance constraint (**I**). Give it a dimension of 15.8 mm.
 - Select one of the horizontal segments and add a horizontal distance constraint (**H**). Give it a value of 31.8 mm.



NOTICE : By applying these constraints it sometimes happens that the rectangle is off center. Using some tools is easier if the sketch is well centered.

- Right click on the screen to unselect all tools.
- While holding down the "shift" key, select one vertex of the rectangle, then the opposite vertex and finally the vertex of the coordinate system.

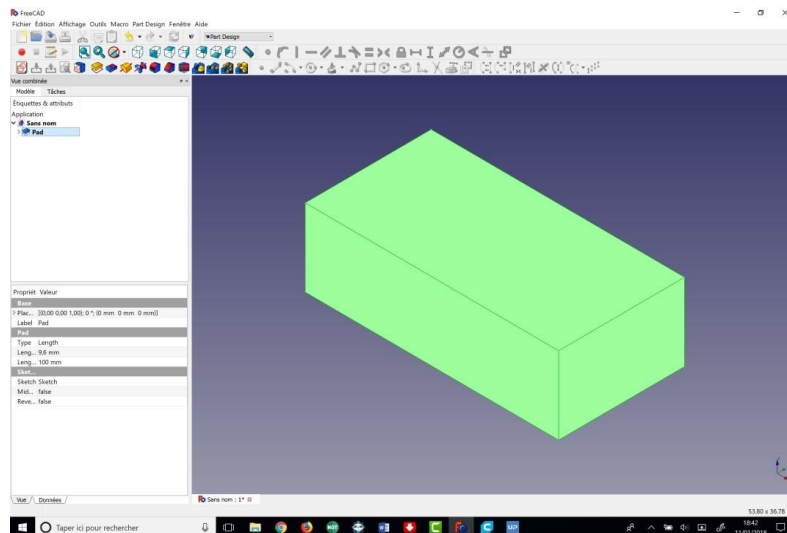
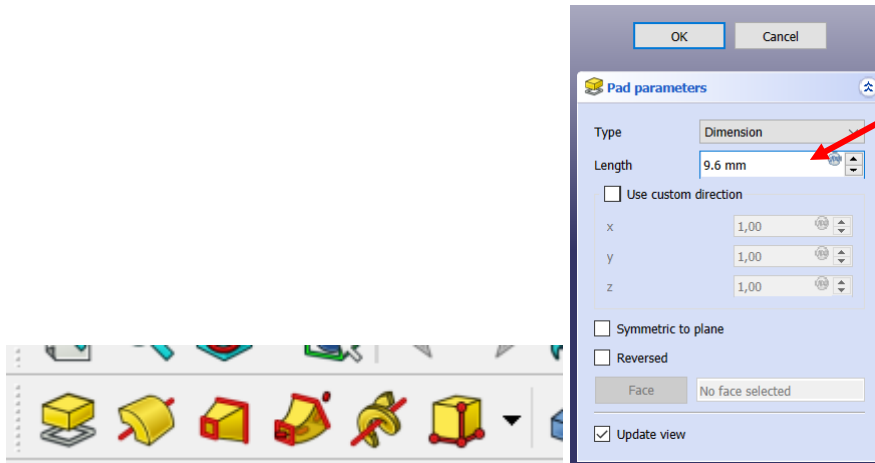


- When all three points are green and have been selected in order, click on the symmetry constraint



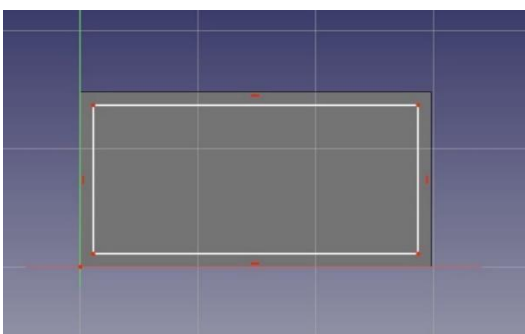
- Our basic sketch is now ready, we can exit the editing mode by pressing the Close button at the top of the task panel, or simply by pressing the Escape key. If necessary, later we can reactivate the editing mode at any time by double-clicking on the sketch name in the construction tree.

- We are going to make what is called in 3D modeling an extrusion. It consists in adding material. Make sure that the rectangle we have drawn is green (which means that it is selected). Select at least one of its sides if it is not, then click on the extrude button (📦) and give it a length of 9.6mm. Click OK.




- We will now define the interior of the block, using the "Pocket" or "Cavity" tool (🔪). To make a "pocket", we will create a sketch on the underside of our block, which will be used to remove part of the block.

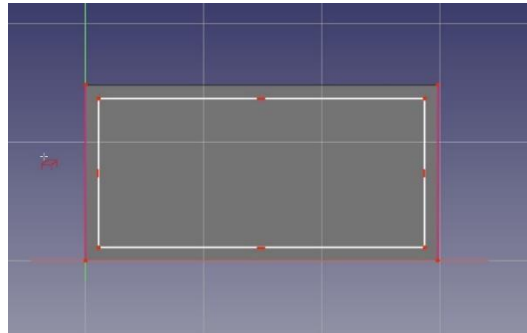
NOTICE: The technique we will use now is extremely important. It consists in drawing a sketch (a 2D drawing) using a face of the figure as a reference.




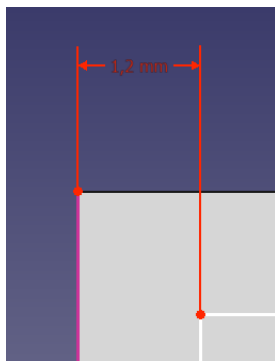
- Rotate the figure (center click + right click) and select the bottom side then press the new sketch button (📄).
- Now we can draw a rectangle, by selecting the rectangle tool (📐) and clicking two vertices diagonally.
- Don't worry about the dimensions, we will constrain the figure later.




NOTICE : Here we will have to work around a strange behavior of the program. Although we have used one of the faces as a reference surface, FreeCad is not able to recognize the edges of our 3D object. But we will need them to impose some constraints.

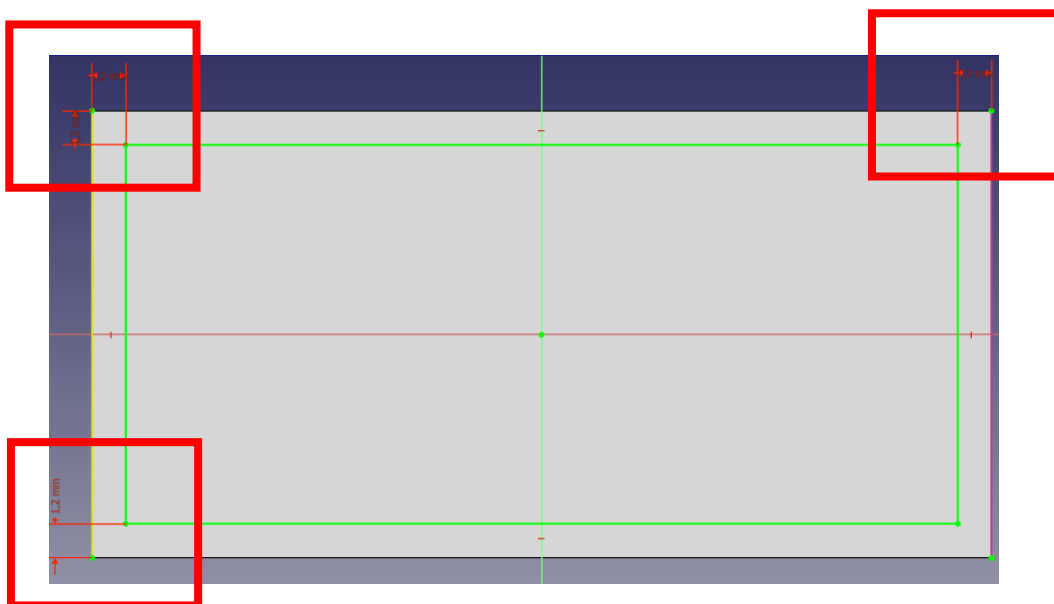
- We will now constrain the rectangle with respect to the bottom face. To do this, we must "Import" some edges of the face with the External Geometry tool () so that you can take a dimension from them. Use this tool on the two vertical lines on the bottom side (these two verticals turn red):




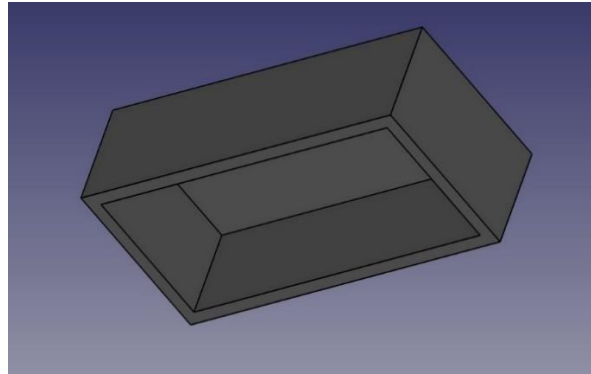
- Select the upper left point of the rectangle and the upper point of the imported left line and add a horizontal distance constraint () of 1,2 mm.








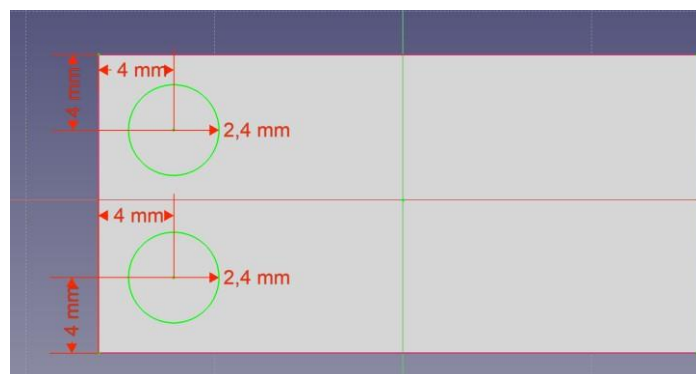
- Select the same points again and add a vertical distance constraint () of 1,2 mm.
- Select the top right point of the rectangle and the top point on the imported right line and add a horizontal distance constraint () of 1,2 mm.
- Select the bottom left point of the rectangle and the bottom point on the imported left line and add a vertical distance constraint () of 1,2 mm.



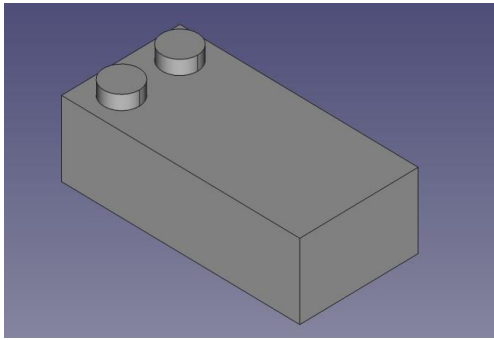
- Exit the editing mode and now you can perform the pocket operation: **with the sketch selected**, press the "pocket" or "pocket" button () . Give it a length of 8,6 mm.



- We will now attack the 8 bosses on the upper side. To do this, as they are a repetition of the same function, we will use the practical Linear Copy tool () of the PartDesign workshop, which allows to model once and repeat the shape.
- Start by selecting the top side of our block. (Rotate: Central Click + Right Click, Move: Central click only, Zoom: Scroll)
- Create a new sketch on it () .
- Draw two circles () placed approximately on the left side of the brick.
- Add a radius constraint () of 2,4 mm to each of them.
- Import the left edge of the base face with the External Geometry tool ()
- Place two vertical and two horizontal constraints of 4mm between the center of each circle and the corner points of the imported edge, so each circle has its center 4mm from the edge of the face:

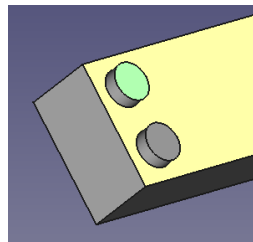


NOTICE : Note how, once again, when you lock the position and size of all the elements in your sketch, it becomes completely constrained. This assures you of the result for the next step. You could change the first sketch now, and everything we did afterwards would be preserved.

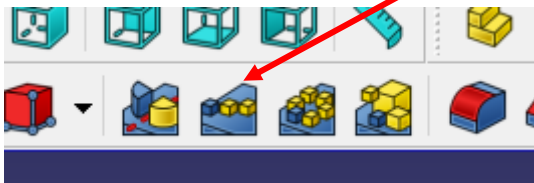


- Exit the editing mode, select this new sketch and create an extrusion (👉) of 1,8mm :

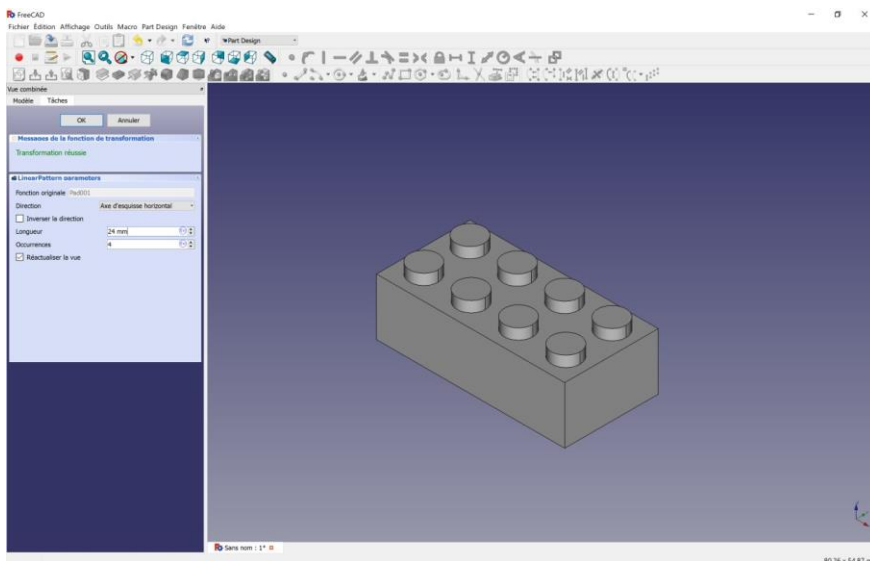
- We can now duplicate our two bosses four times, so we'll have eight. Select the last bump we just created.



- Press the linear copy button (👉).

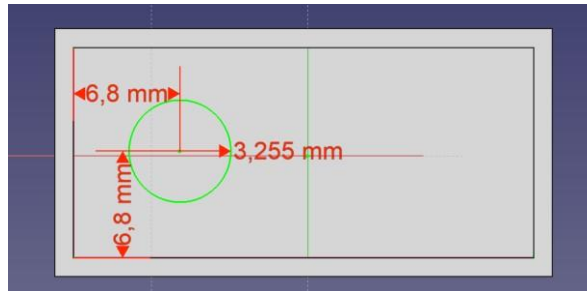


- Give it a length of 24 mm (which is the total amplitude we want to occupy with our copies), in the "Horizontal sketch axis" direction, and make 4 occurrences:

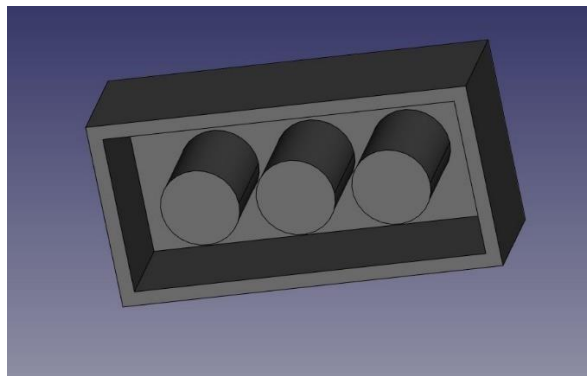


Now let's work on the three "tubes" that fill the void we created on the bottom side !!!

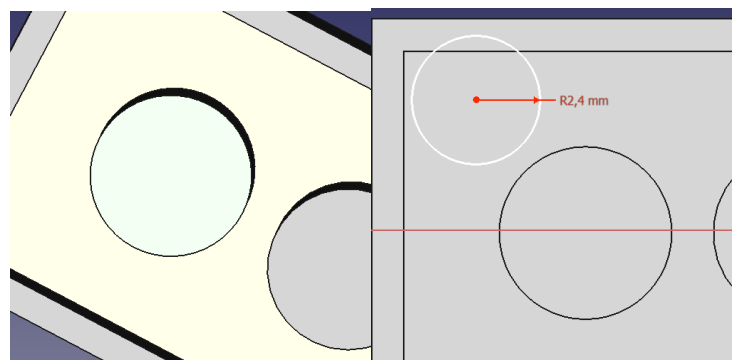
- Select the face that is at the bottom of the space we dug earlier inside the block.
- Create a new sketch, add a circle with a radius of 3.255 mm, import the **bottom** left edge of the inner space and position the center vertically and horizontally 6.8 mm from the top corner of the face:






- Exit edit mode, select our circle and extrude to a length of 8.6 mm.
- Create a linear copy of this last extrusion, give it a length of 16mm and 3 hits. We now have three bosses in the cavity:

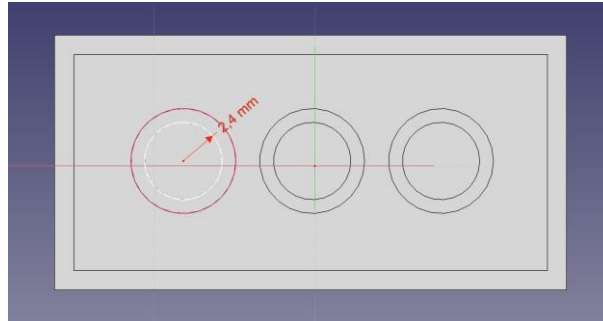


- Now let's make the last holes. Select the circular face of the first of our three bosses.
- Create a new sketch, import the circular edge of our face, create a circle with a radius of 2.4 mm

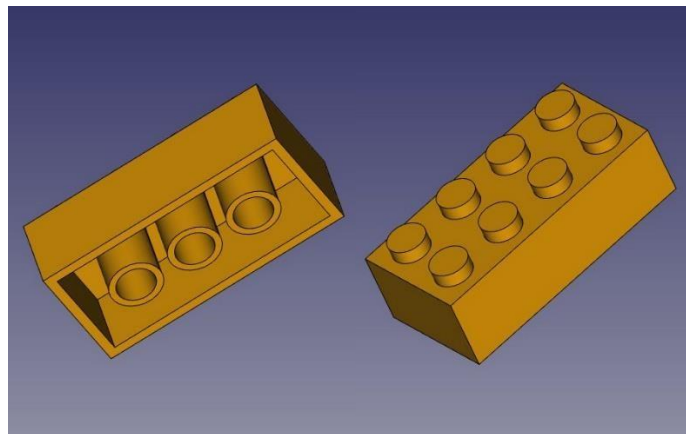


- We now have to add a coincidence constraint () between the center of our circle and the outer circle of our first bump. You will notice that the outer circle is unavailable. This is normal, we need to import it ().

- Once you have the two circles, select the two centers by holding down shift and click on the coincidence constraint ().
- We now have a perfectly centered circle, and once again completely constrained:



- Exit the editing mode and create a pocket from this sketch, 8.6 mm long.
- Create a linear copy of this pocket, with a length of 16 mm and 3 hits.



You will notice that the modeling history or construction tree (what appears in the tree view) has become quite long. This is valuable because every step of what we have done can be modified later. Adapting this model for another type of brick, for example one with 2x2 bosses, instead of 2x4, would be a piece of cake, we would just have to change some dimensions and the number of occurrences in the linear copies. We could also easily create larger pieces that do not exist in the original Lego set.