Computer Aided Design Exercise for 3D fabrication using FDM

Download FreeCAD from https://www.freecadweb.org/downloads.php. This tutorial was written for FreeCAD 0.18 Win.

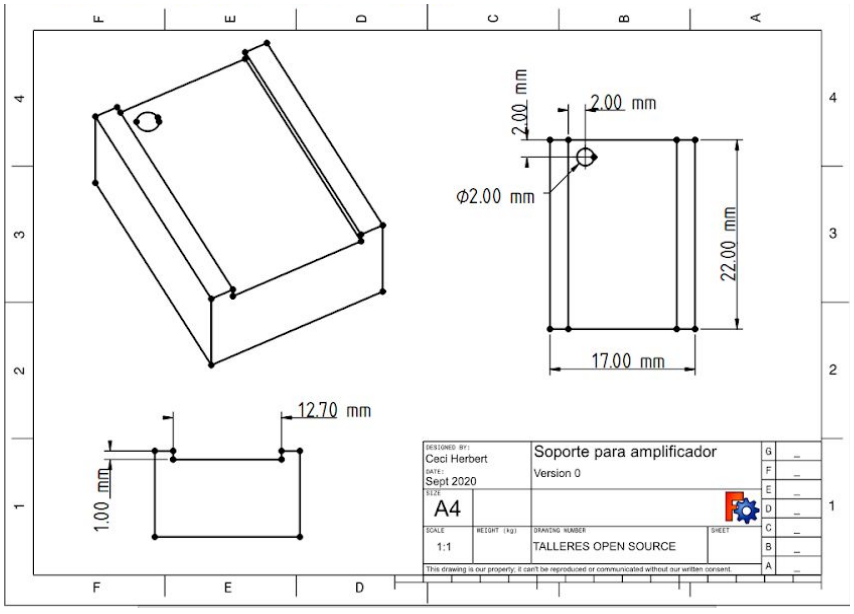
It was already obsolete when I wrote it since this software is permanently under development.

Always check for updates on their forum, repository and twitter @FreeCADNews

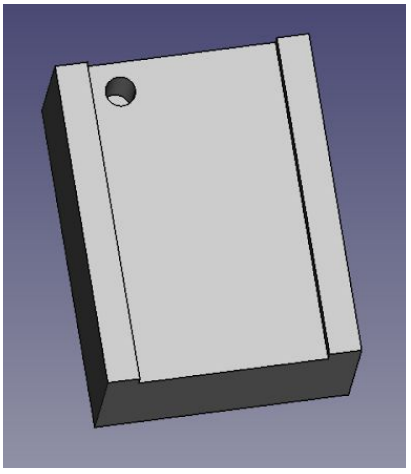
https://twitter.com/FreeCADNews/status/1304158949055307778?s=20

Workshop repository with support files:
https://github.com/talleresopensource/ciclo-01/tree/master/encuentro04

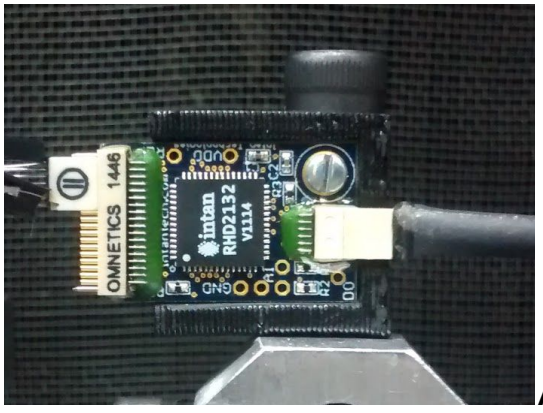
What are we designing? A support for an electrophysiology amplifier board.



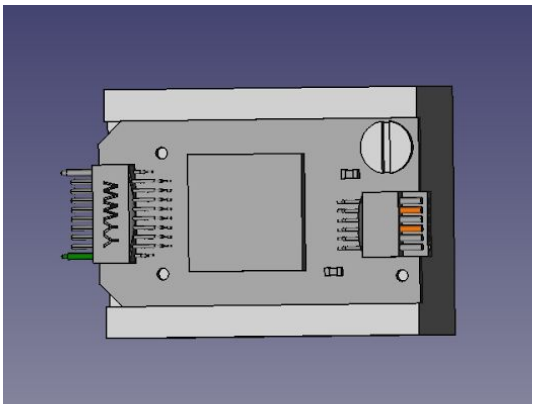
Technical diagram



Finished part



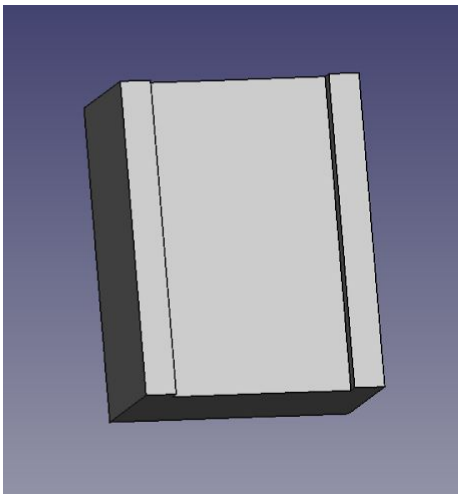
Real photo

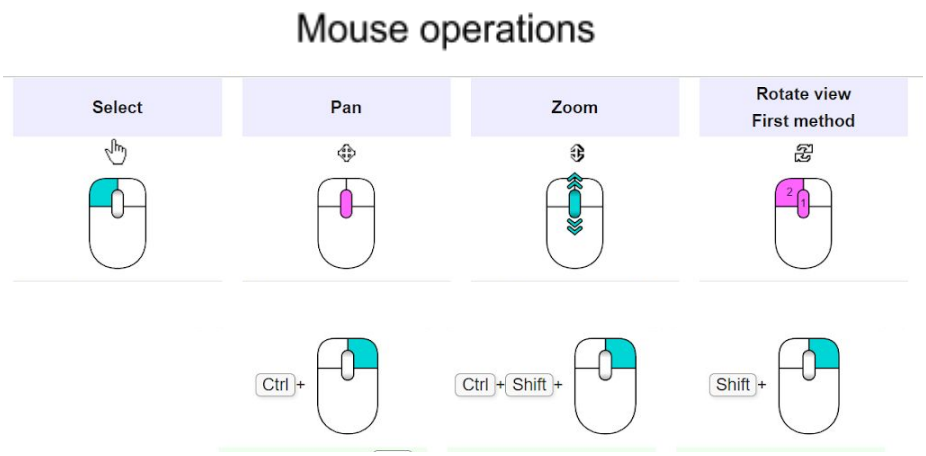


Assembly

Exercise Parte A: Amplifier support

Final result:





1) Go to the “Part Design” workbench (note that it is not the “Part” workbench), by leaving the “Start” workbench in which the program initializes using the workbench selector.

So 

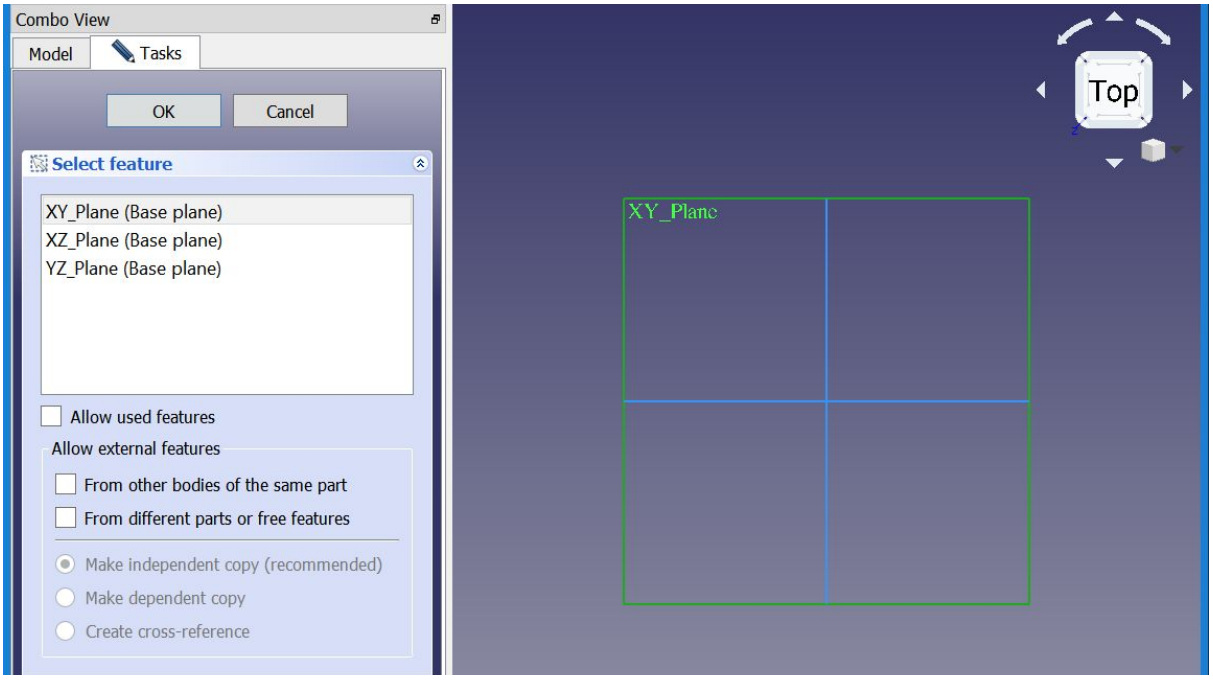
instead of 

2) Create a body  .

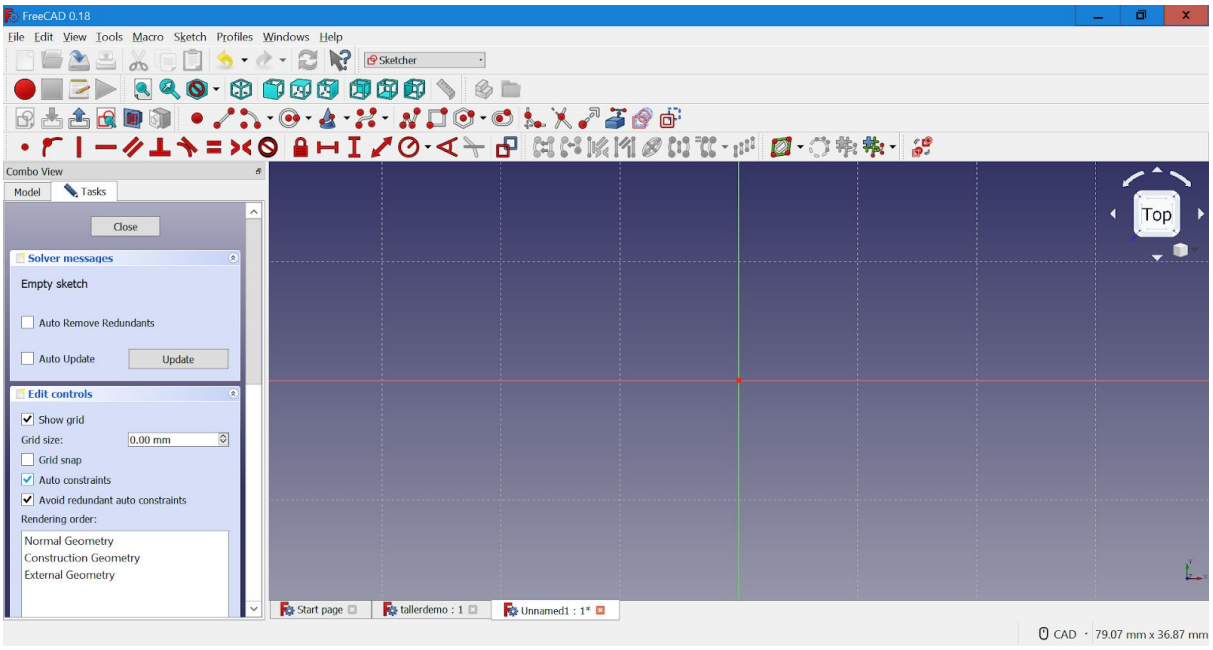
Main body of the amplifier support

3) Use the “Create a new sketch” tool  or select “Create sketch” from the menu.

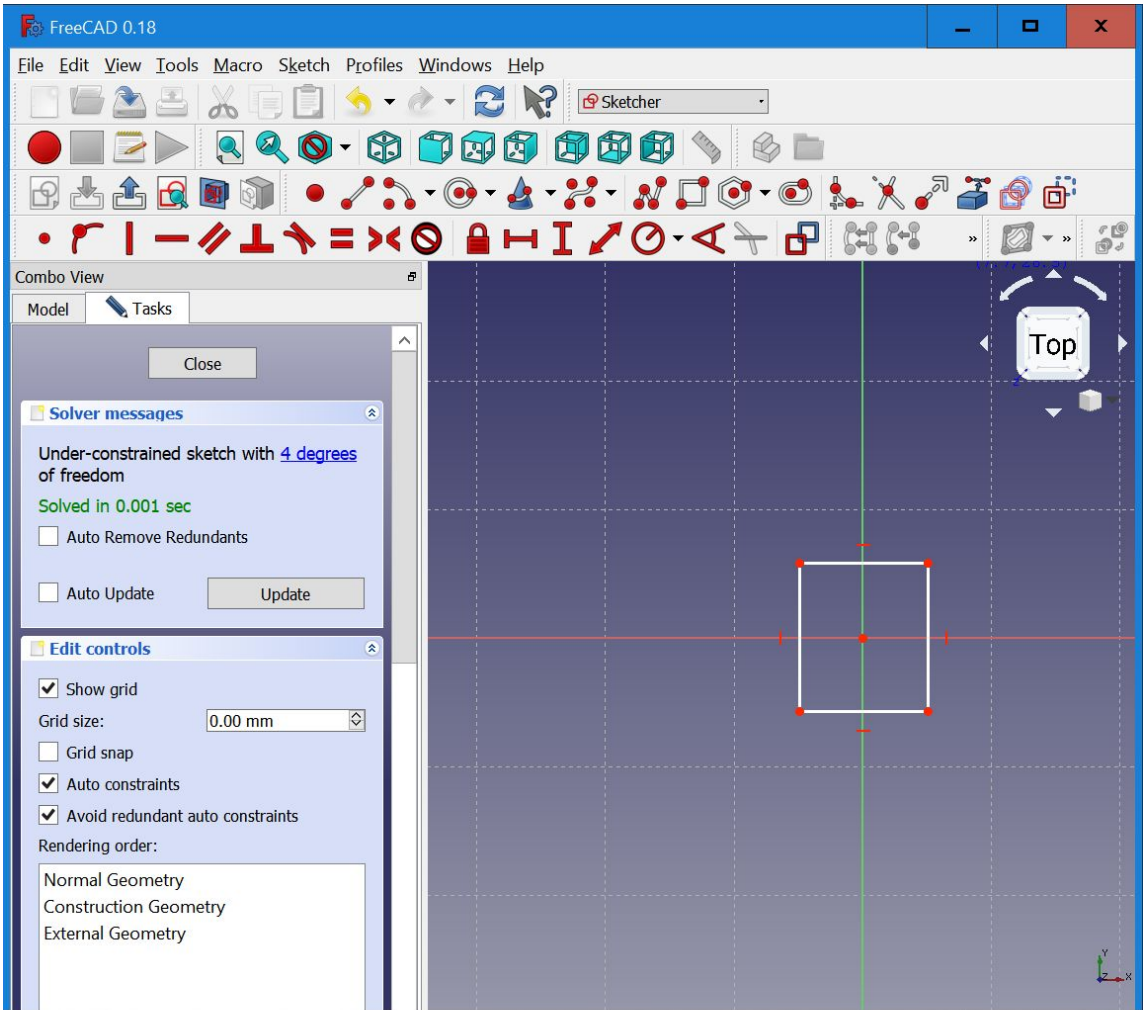
4) Select the XY plane on the list or on the workspace. This will be the top face of our body. It will be highlighted in green. Click OK.



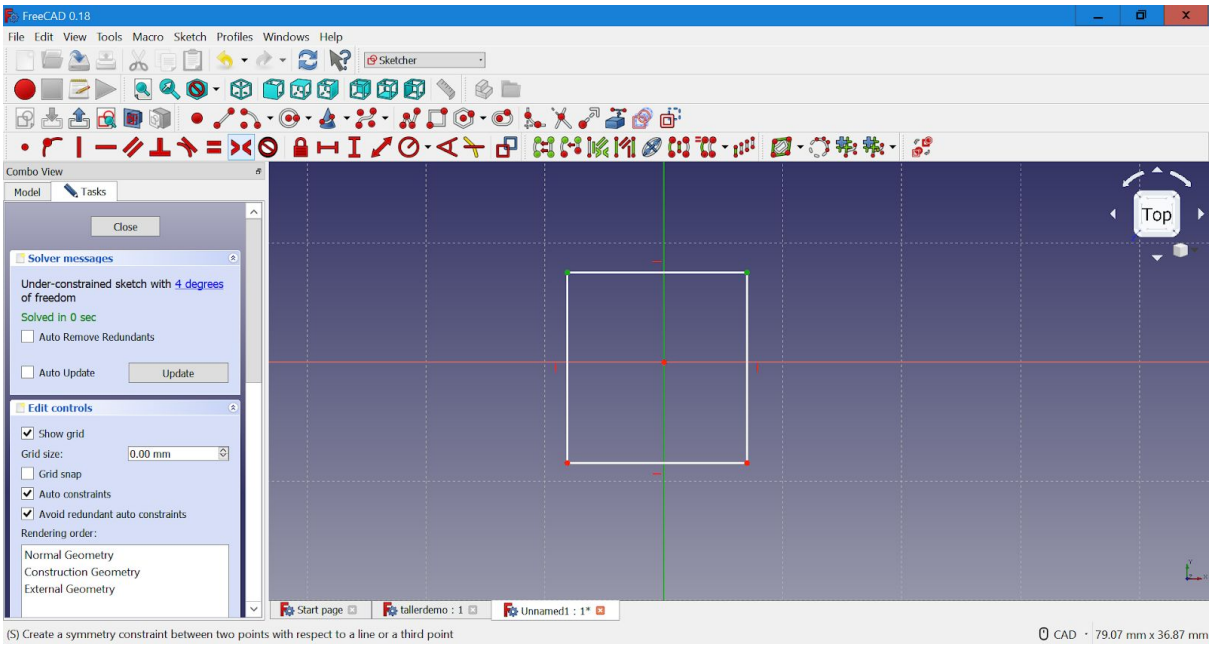
5) IMPORTANT: check and uncheck “Auto constraints” and “Avoid redundant auto constraints” the first time you use the program. *This is a bug in this version and otherwise those options will not work.*



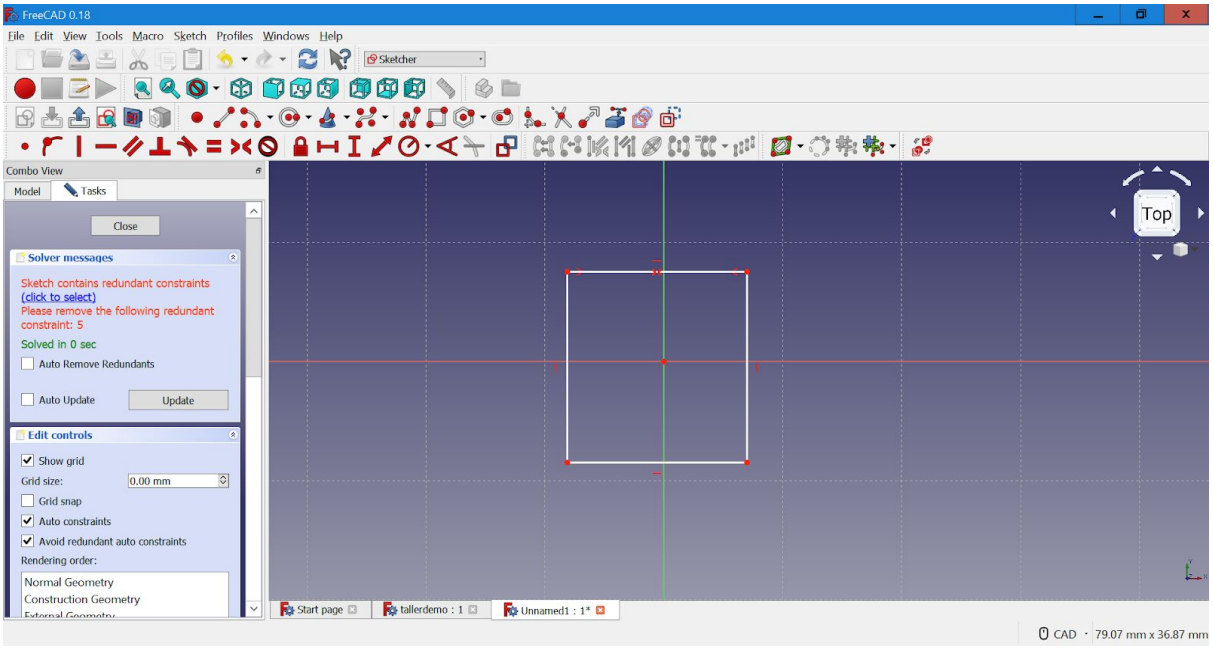
6) Use the rectangle tool  to draw the sketch for the main body. In this case it is just one rectangle. We will define its position and dimension in the next few steps. Press Esc to deselect the tool.



7) We will reference the sketch to the coordinate system. For this, we will constrain our sketch with two symmetry constraints referenced to the two planes orthogonal to the plane we are working on (green and red line).
For the reference to the green plane, select the two top vertices of the sketch and the green line (hovering over the objects will highlight them in yellow and, once selected, they will turn green), and click the symmetry constraint  .

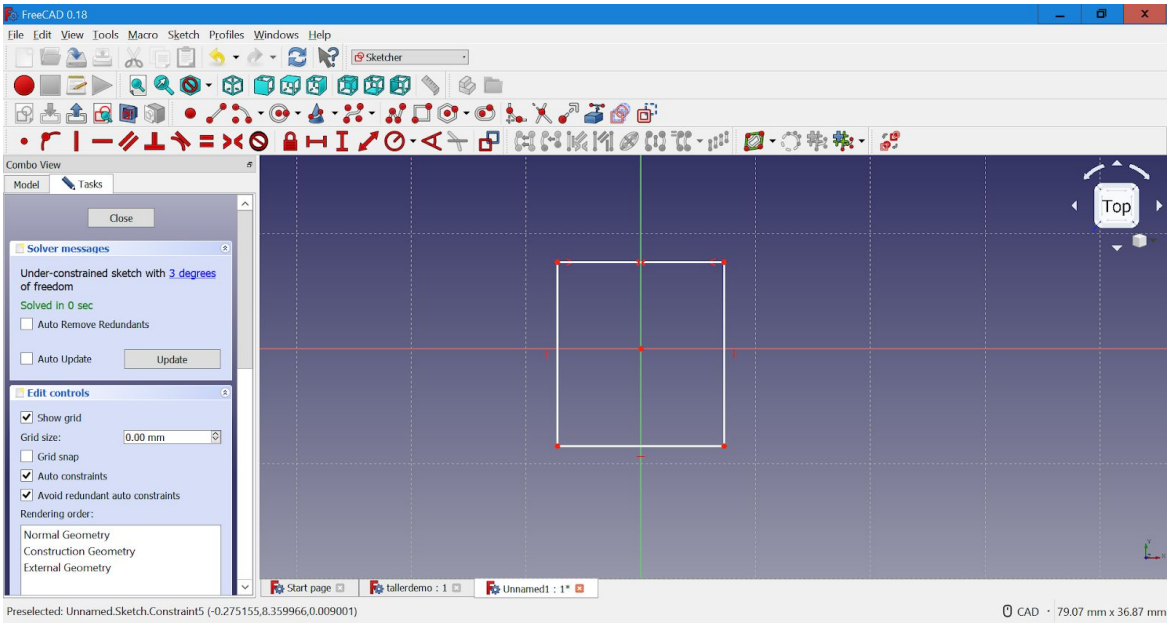


The result is a redundant constraint, since a horizontal line constraint was created automatically for the top border when we drew the original rectangle and this is redundant with making both vertices symmetric to the green plane.

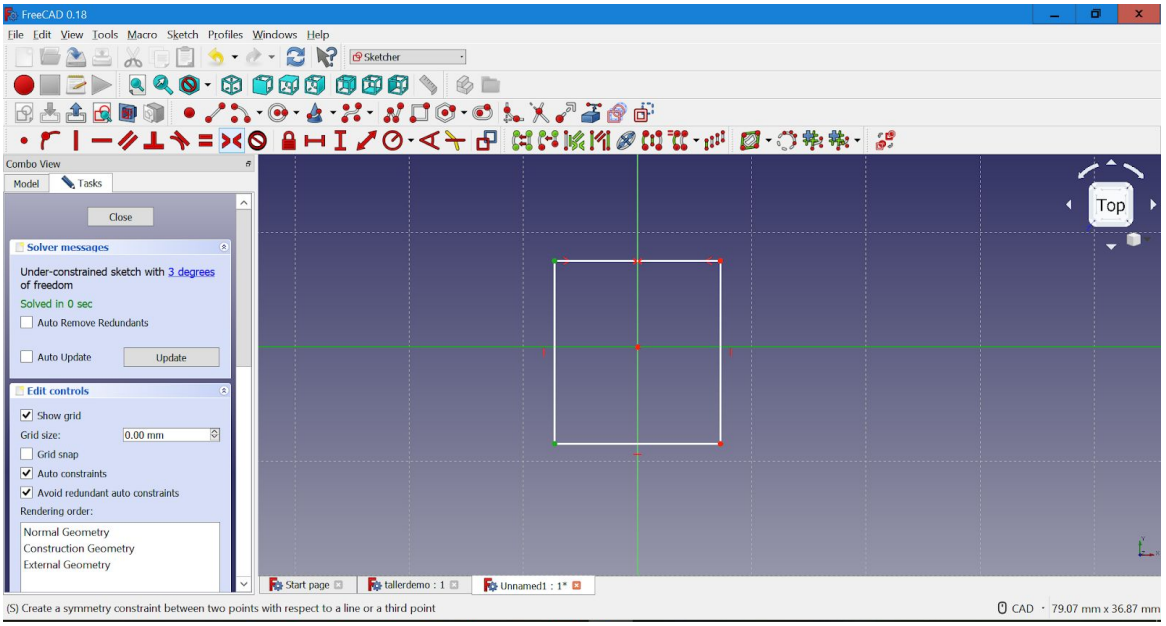


Remove the redundant constraint by selecting it (the short horizontal red line beside the border), and pressing Del.

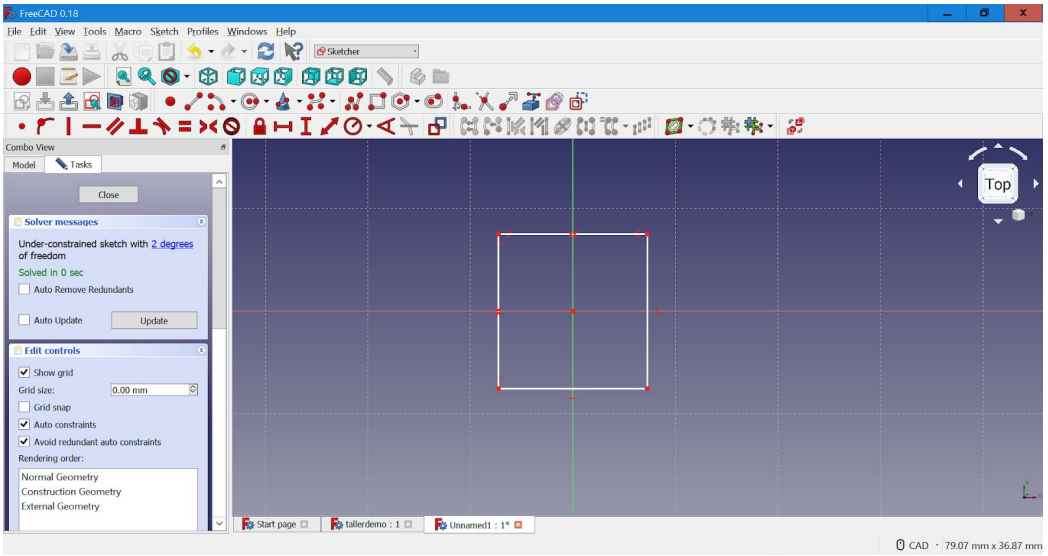
The sketch is now symmetric with respect to the green plane:

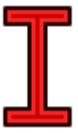


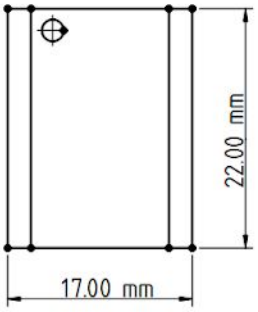
Repeat the steps for one of the sides with respect to the red plane.



Result:

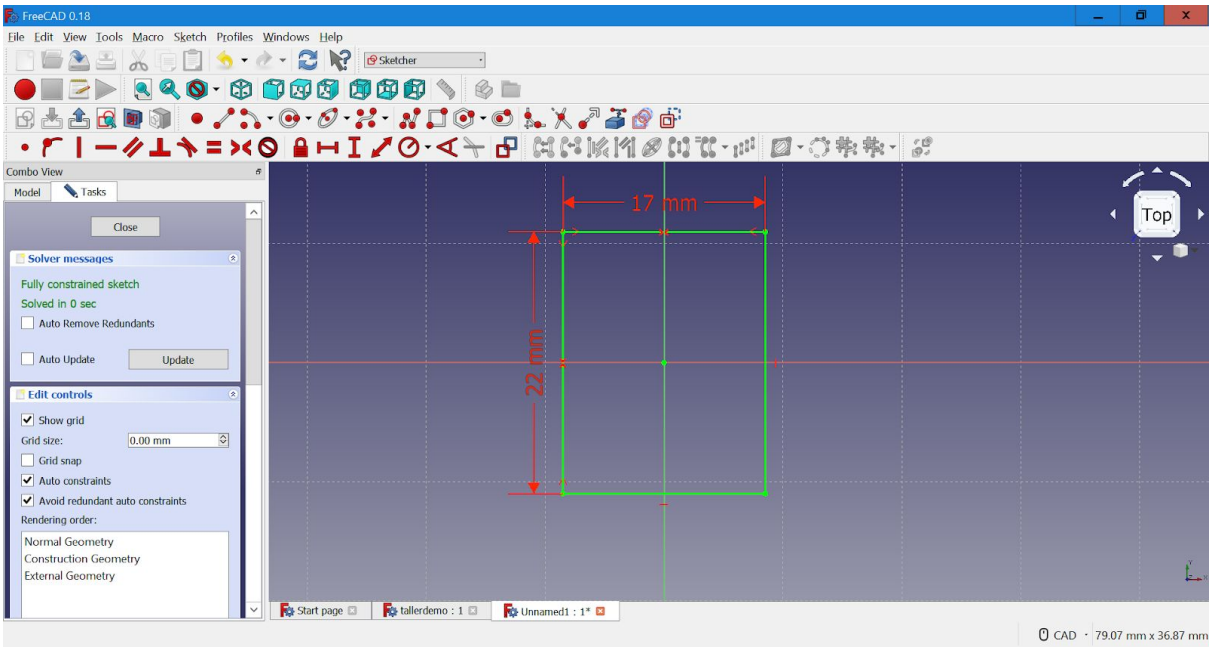


8) Add dimension constraints using the horizontal  and vertical  distance constraints according to the following diagram:



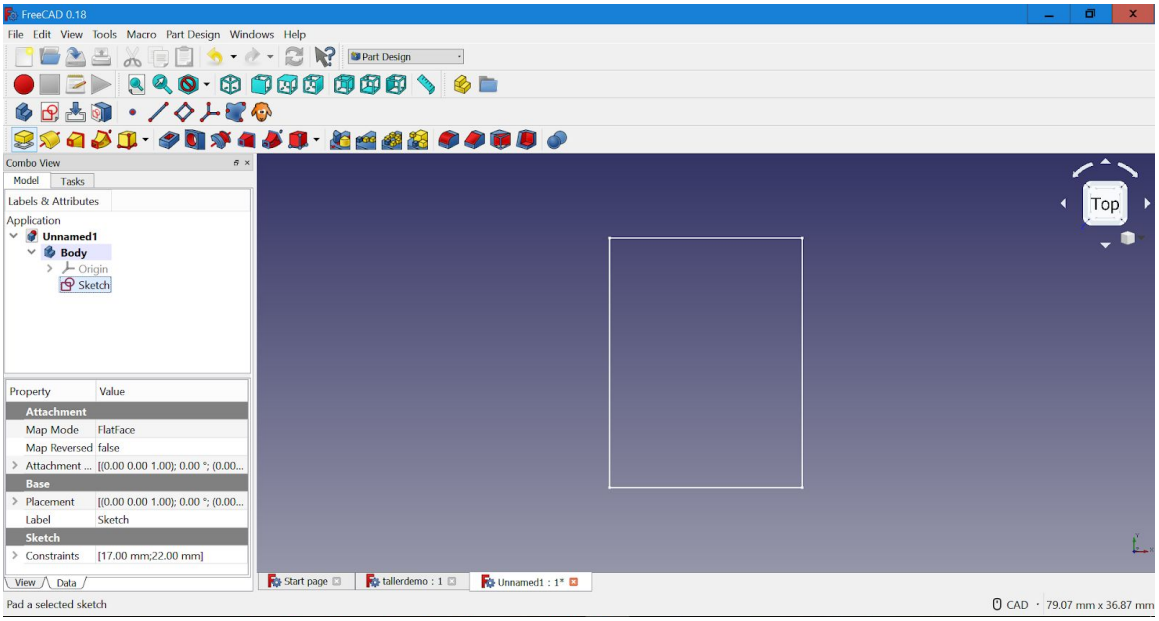
Top view

Result: fully constrained sketch. The sketch is highlighted in light green. This is good practice. Click Close or press Esc on your keyboard to finish.

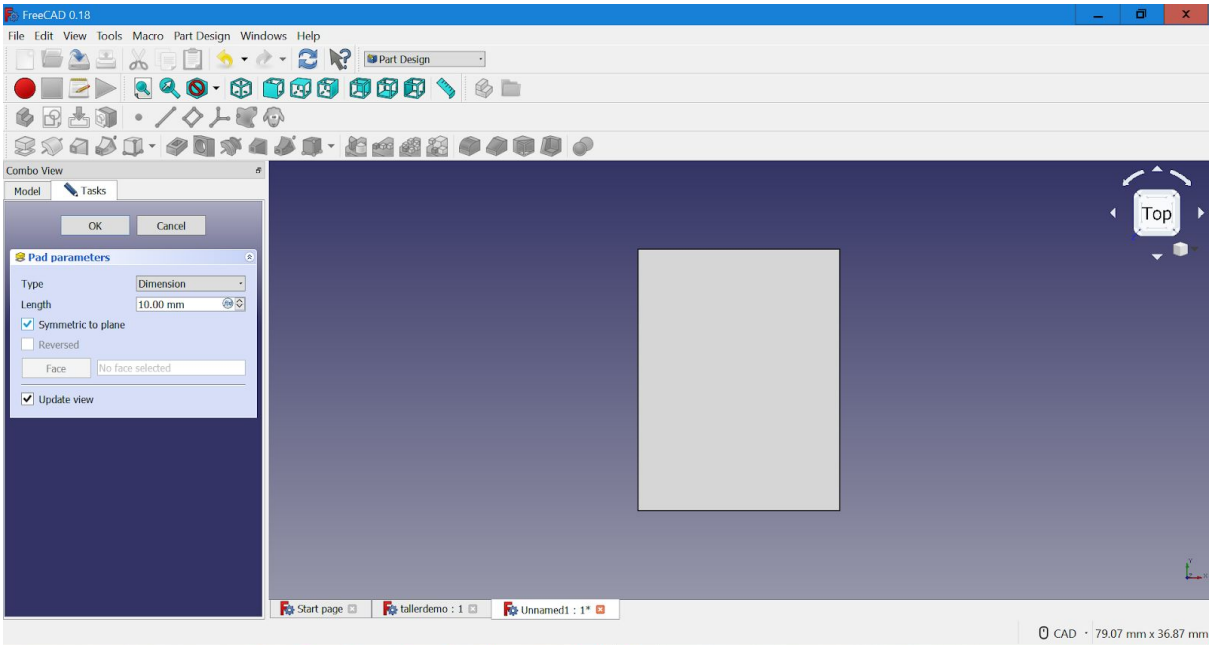


It is also good practice to name your sketches, features, bodies and parts to keep things tidy.

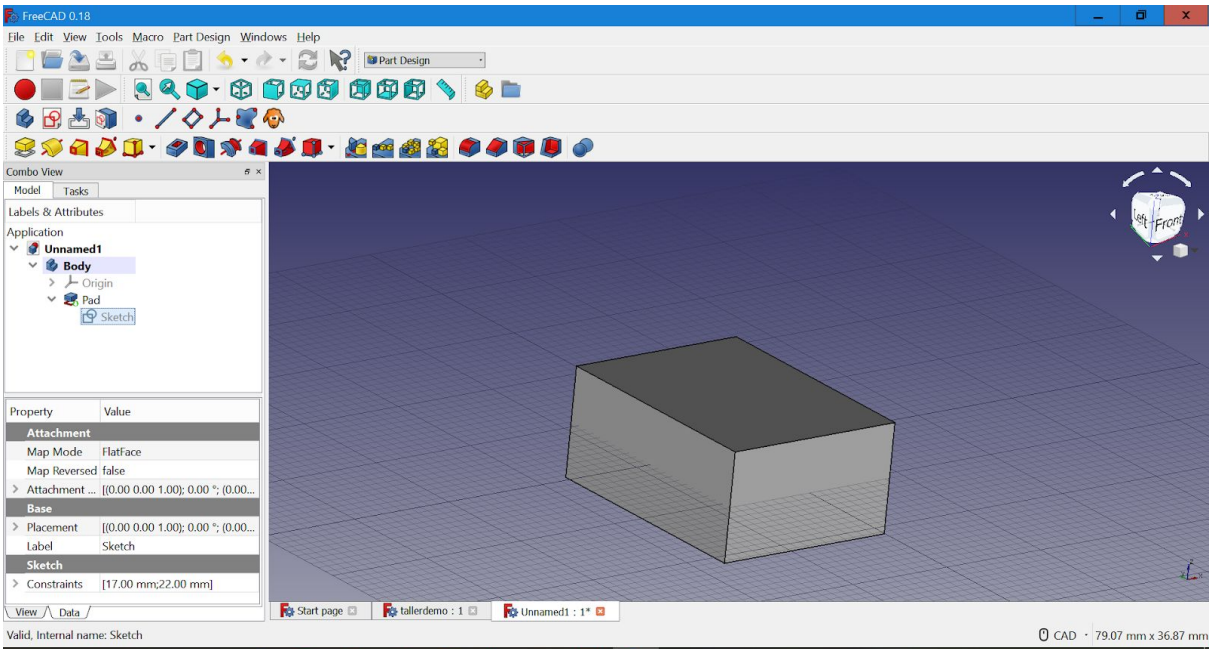
9) Add volume to the sketch using a feature to create the support. Click the additive operation Pad  .



Write the desired dimension value needed and click “Symmetric to plane”.

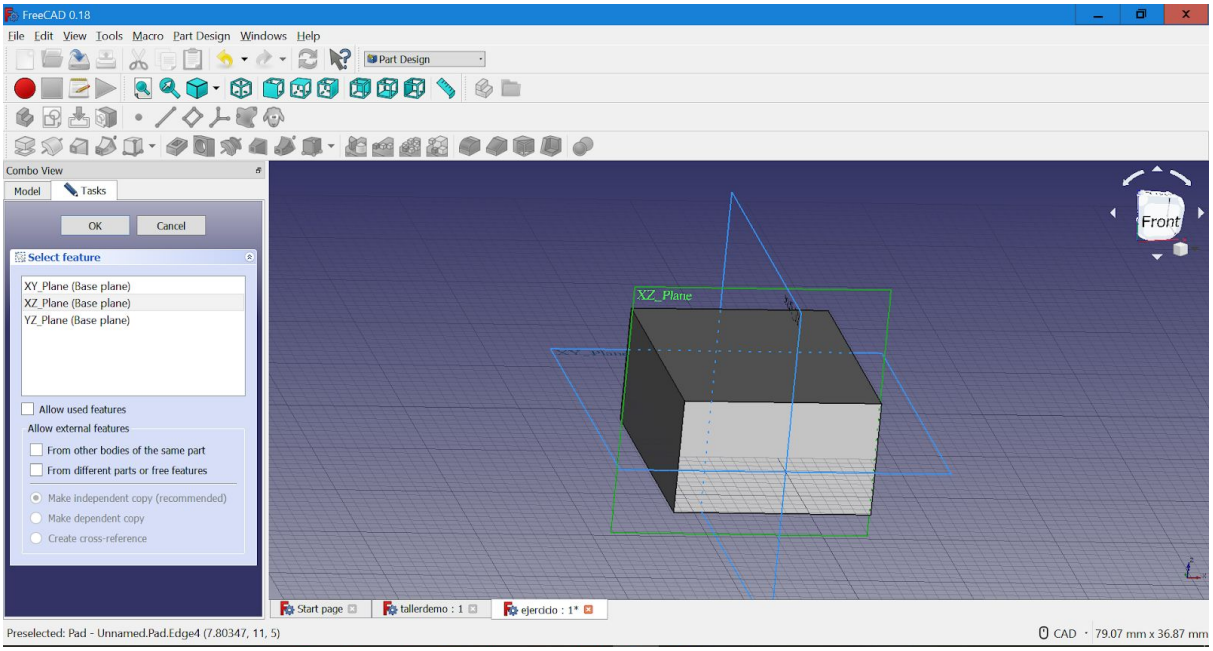


Result: you made a block (main body of the amplifier support)! The volume is symmetric to the sketch plane. This feature now is dependent on the underlying sketch.

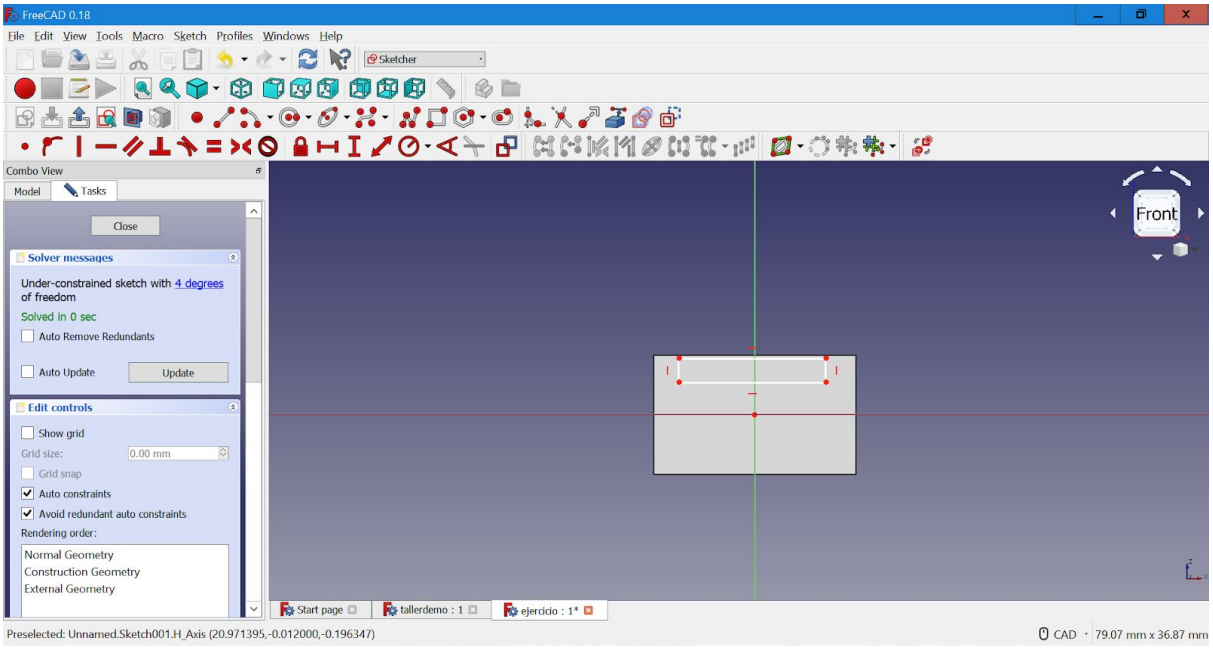


Holder groove for the amplifier

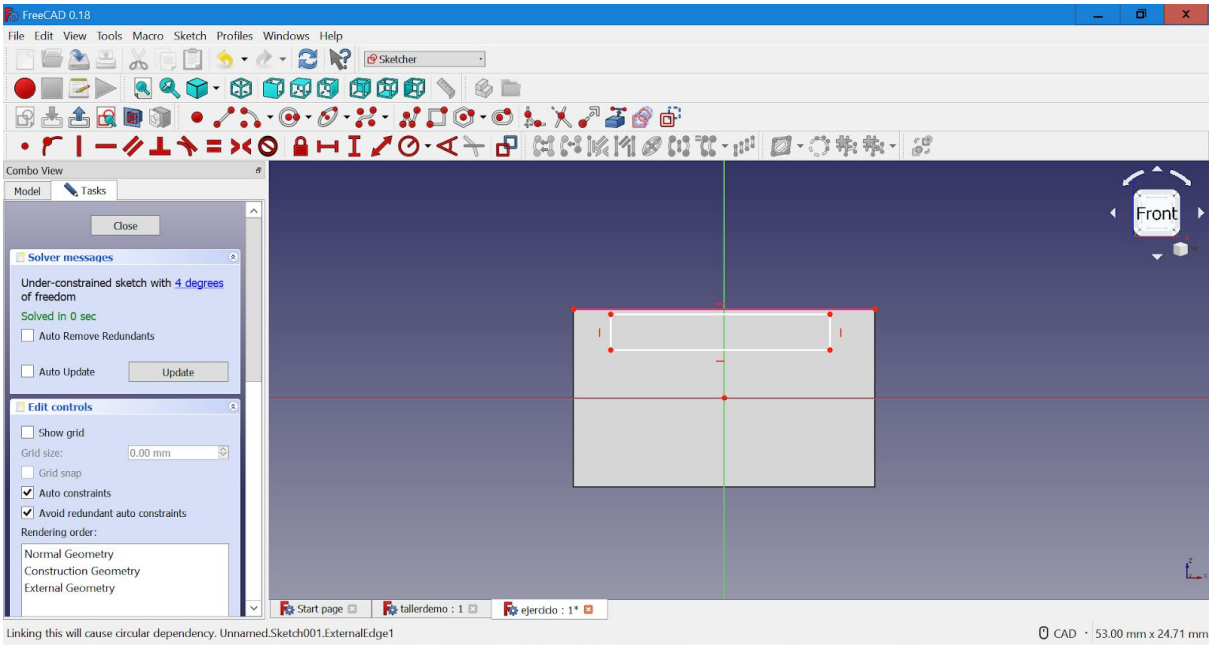
10) Add a square groove to hold the amplifier. To do this, we will sketch a rectangle of the desired width and depth and we will cut the block (main support) from the side using this sketch. Create a new sketch using the  tool. Select the XZ plane (lateral frontal face of our body).



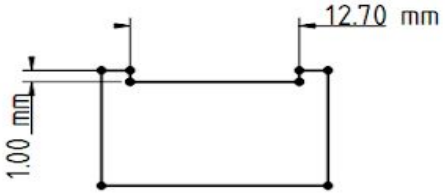
11) Use the rectangle tool  to draw the sketch we will use to carve out the block. Since we are sketching on a plane that goes through the body, we need to use the  tool to change to a section view so as to see the sketch within the body.



12) Since we want the square groove to be aligned with the top edge of the block, we need to reference our new sketch to the body we created previously. To do this, we must use the external geometry tool  and click on the top edge of the body section. It will turn pink and we will be able to use it as a reference to add constraints to our sketch.



13) Add the dimension constraints and any additional constraints necessary for the square groove to have the size and position needed to hold the amplifier.

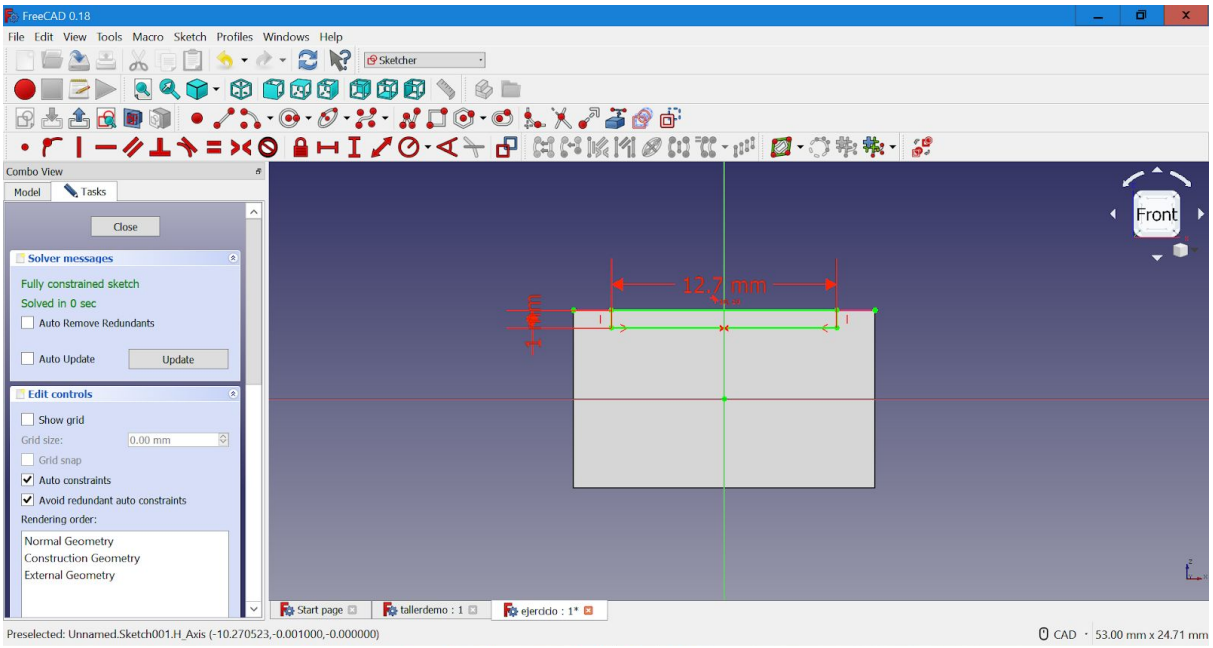


Frontal lateral view

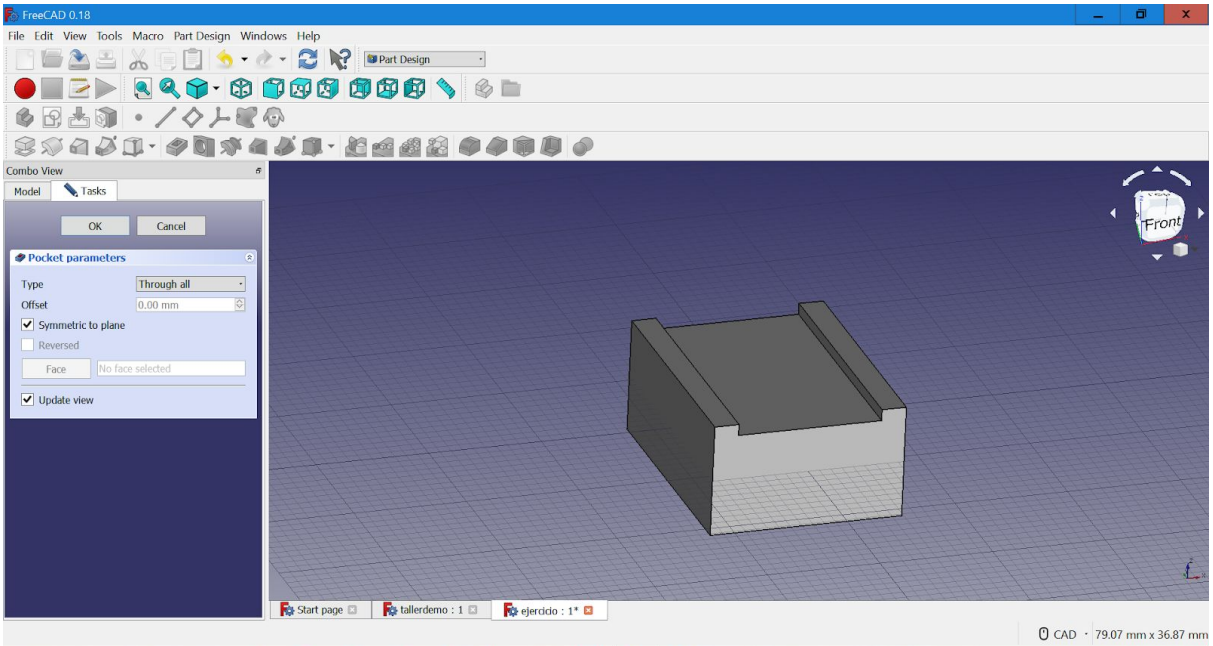
Which constraints would you use to relate the holder groove with the main body of the support?

(Hint: there are a couple of options whether you want to concentrate on the size of the ridges on either side of the groove or on centering the groove on the main body.

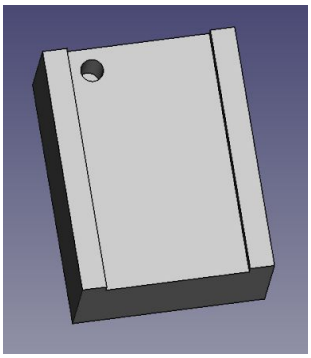
Result using a “point on object” constraint to make one of the top vertices of the rectangle sketch coincide with the top border of the main body, a symmetry constraint around the green plane and both dimension constraints:



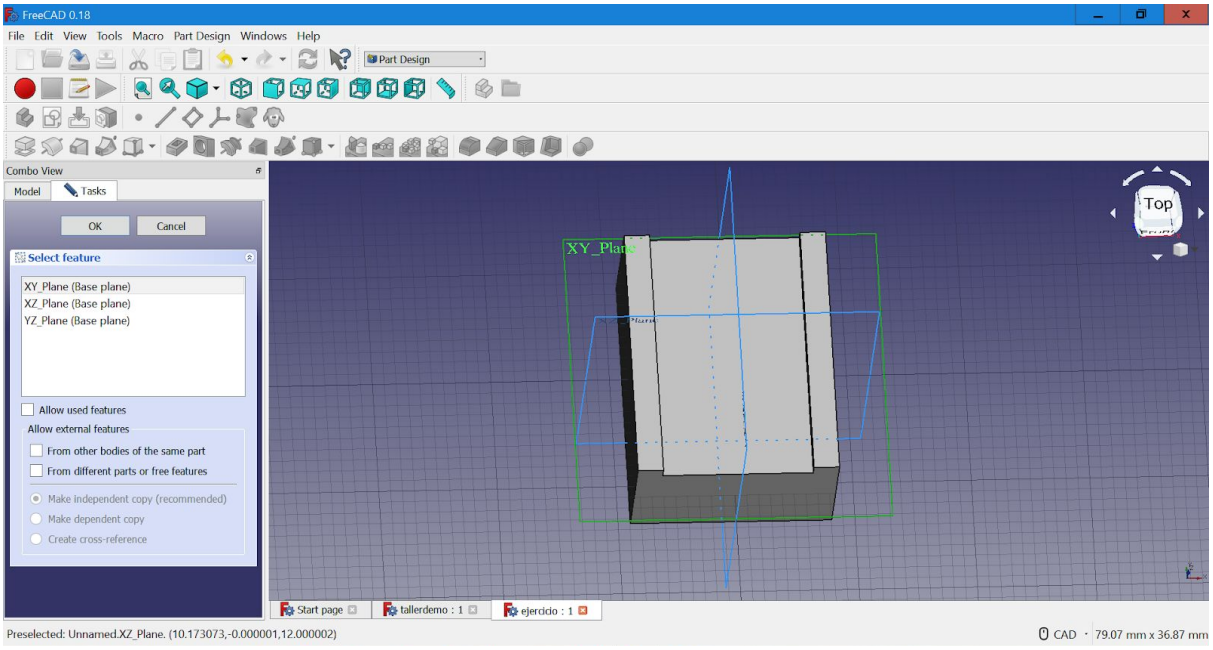
14) Use the subtractive tool Pocket  to cut the main body of the support from the front side using the sketch you just created. Select the option “Through all” and check “Symmetric to plane”.



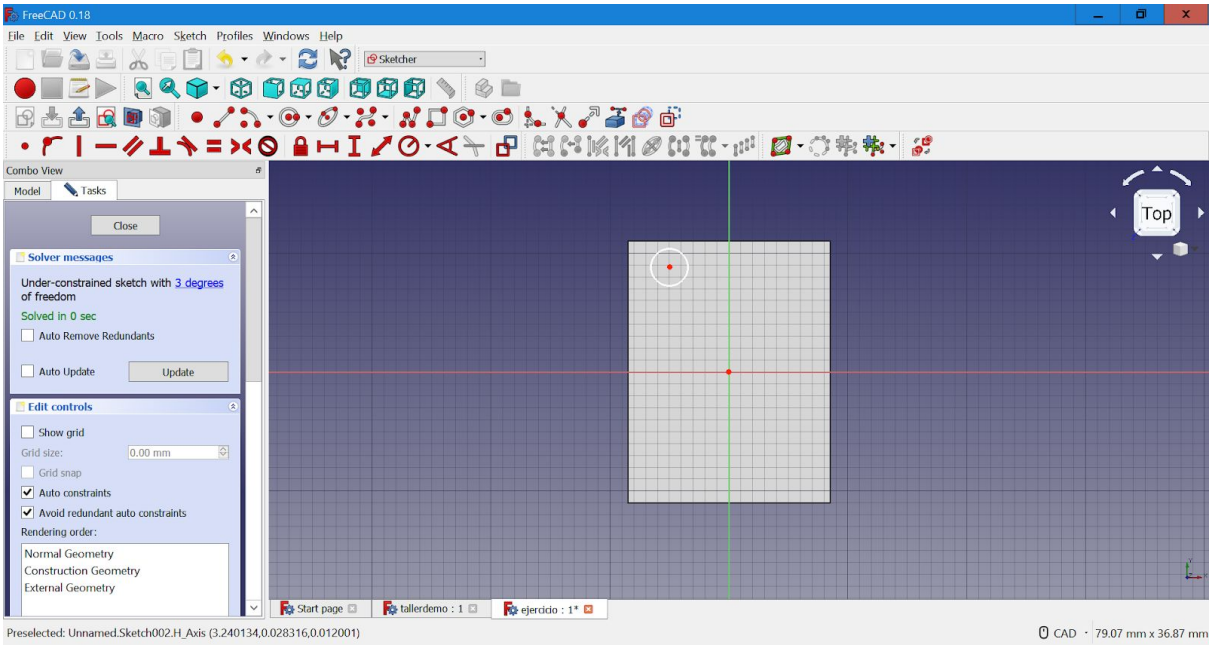
Exercise Part B: add a hole to fix the amplifier to the support

Final Result: 

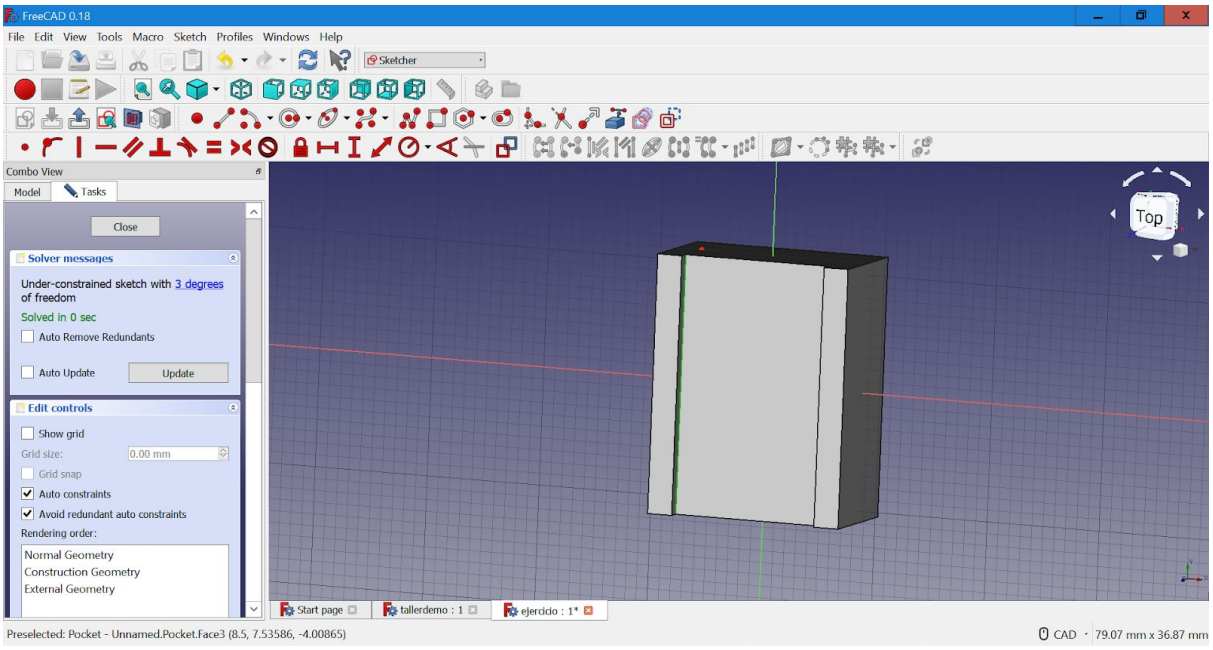
1. Make a new sketch on the XY plane.



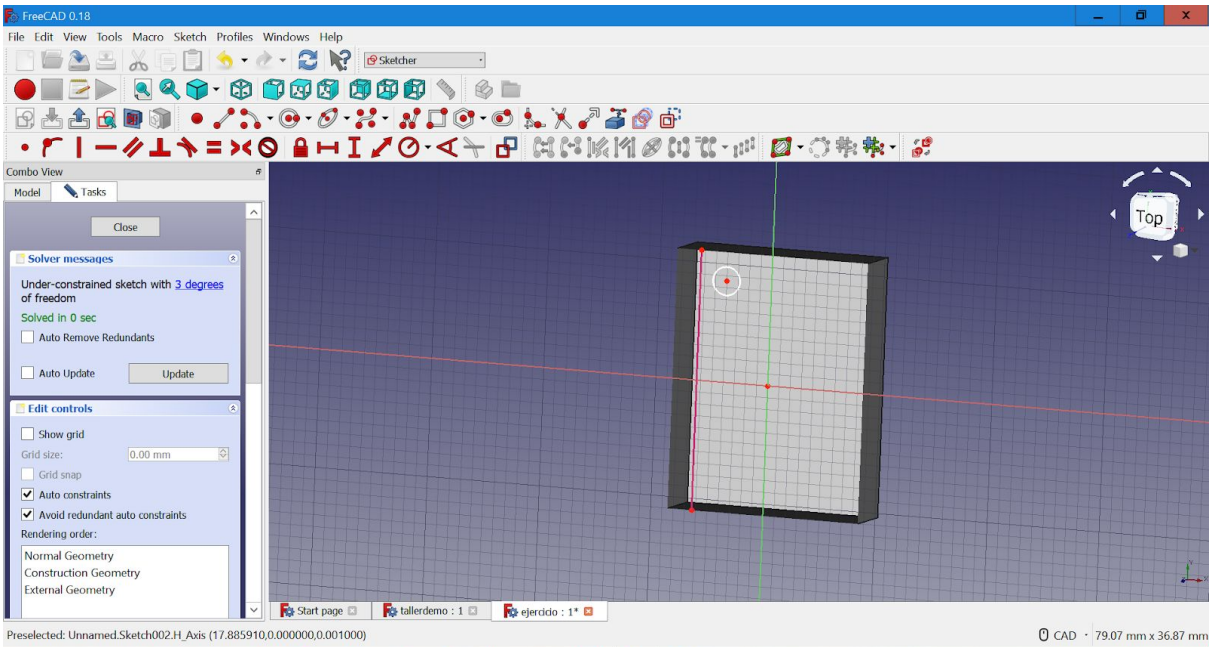
2. Change to the section view and draw a circle with the  tool.



3. Use the external geometry tool to define the lateral internal edge of the groove that we will use to add constraints to our sketch.

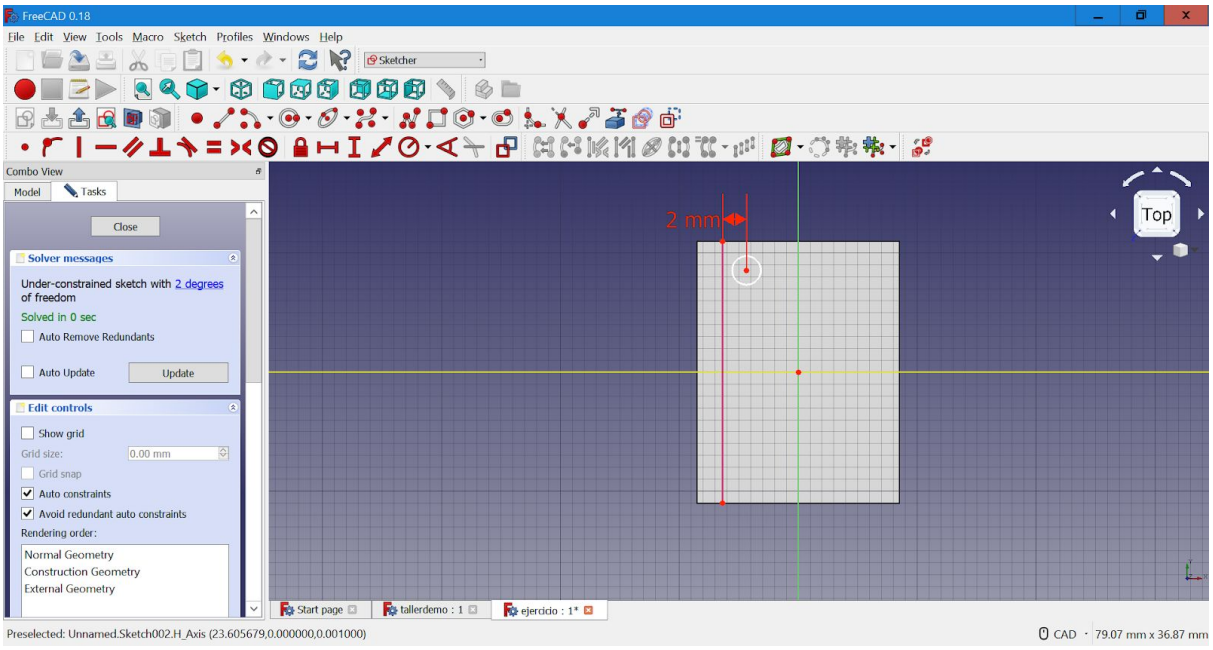


This is the section view:



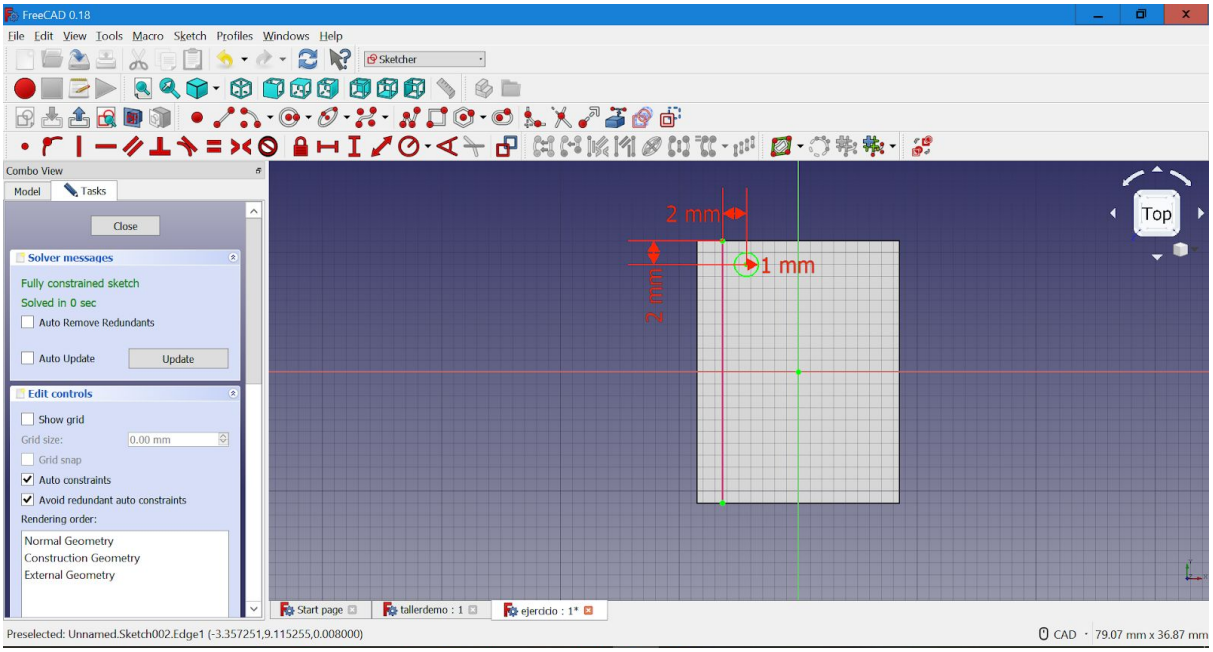
Think about what constraints you would use to position the circle on the sketch

4. Add horizontal and vertical distance constraints between the centre of the circle and the vertex of the lateral interior border.

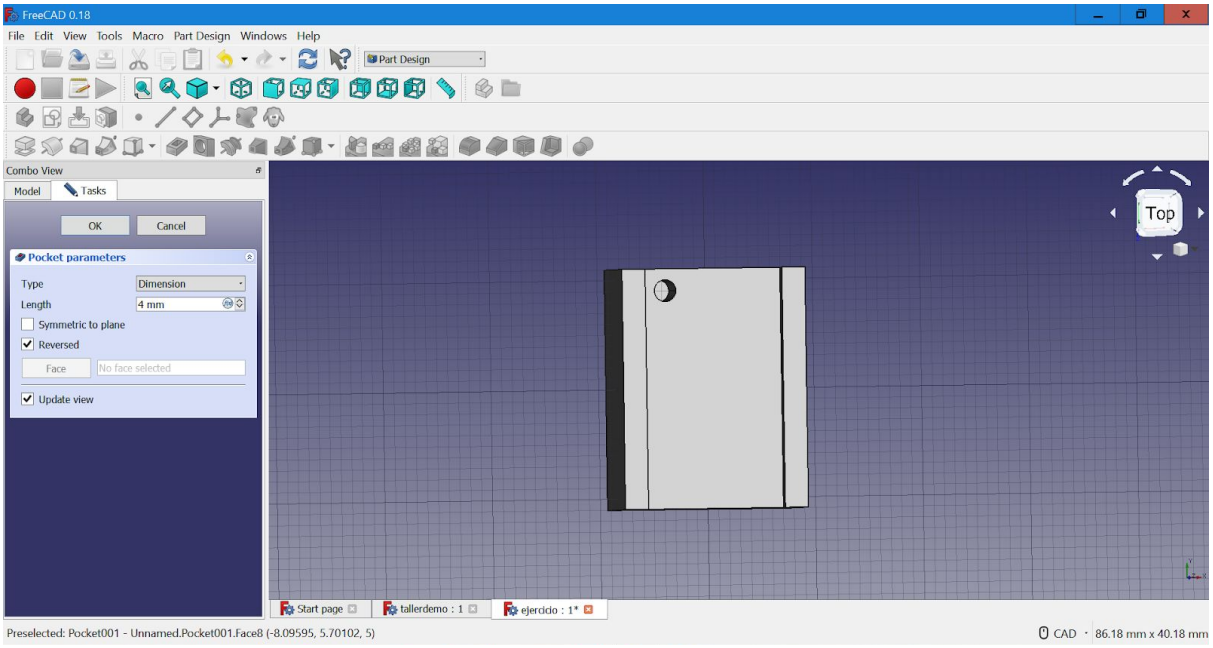


5. Add the circle dimension constraint using the radius constraint  .

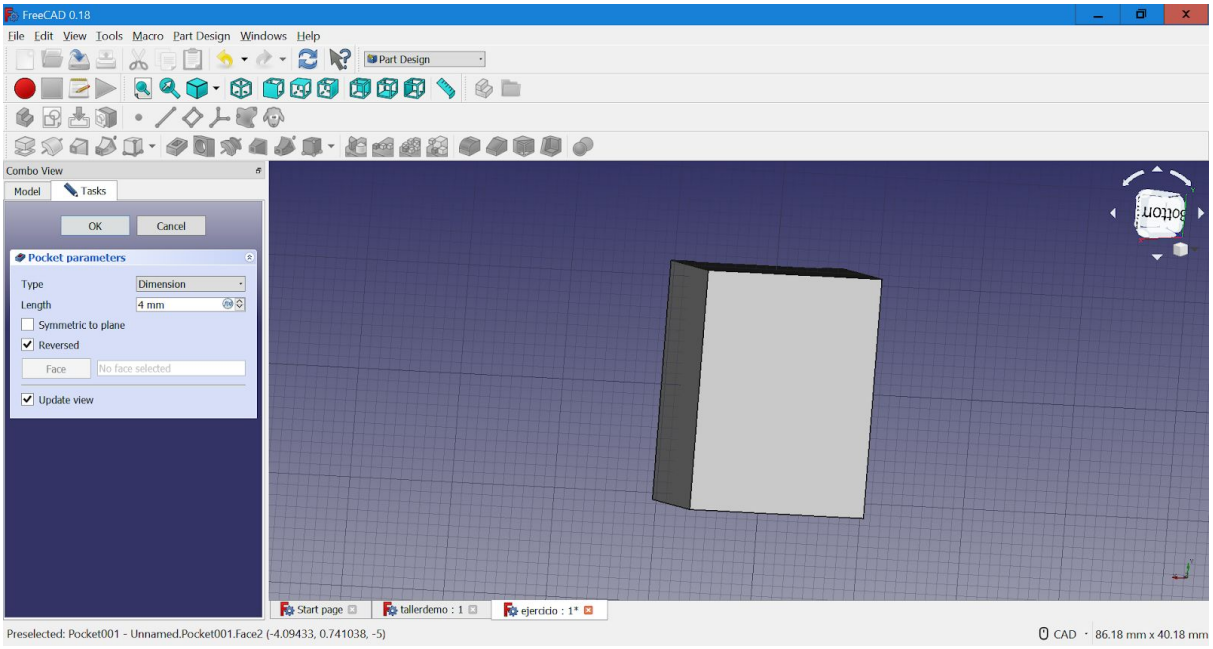
Result:



6. Make the hole using the subtractive tool Pocket to cut the block using the circle sketch that you just created. Select the option “Dimension” and the desired length and check “Reversed” so it goes up to the top of the body.



This is the bottom (no hole):

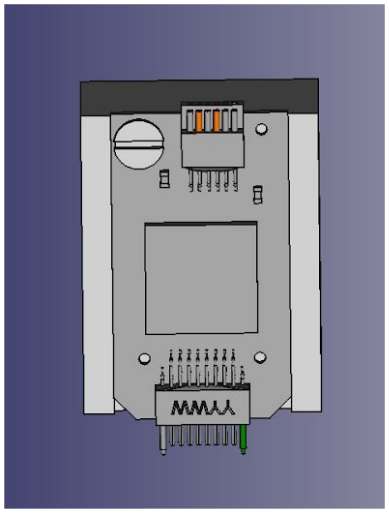


7. Export the part. Select the body component within the model tree, go to File > Export and save as .step.

   Challenge: you can repeat the steps for exercise B to add a hole on the side of the part that can be used to fix the support to the setup as shown in the photo at the start of the experiment (not shown on the diagram).

Exercise Part C (Extra!): align and assemble components

(this section requires the body created in Part A and B, the part Amplificador.step, installing workbenches “A2Plus” and “Fasteners”). Other people use the “Assembly4” workbench, and work is underway to unify workbenches for assemblies.

Final result: 

Before starting exercise part C

Download Amplificador.step from the repository.
https://github.com/talleresopensource/ciclo-01/tree/master/encuentro04
If you did not do exercise part A and B and you want to practice part C, download pieza_ejercicioAB.step.

Install “fasteners” and “A2Plus” workbenches as addons.

How to install addons?

1. Tools -> Addon manager
2. Click OK on the dialogue box
3. Find each *addon* and click the install button
4. Restart FreeCAD

Steps for exercise part C

1. Create a new file by going to File > New.
2. Add the components you need to assemble

   Imported components will keep their external dependencies and can be edited. For well defined components such as fasteners, it is useful that they cannot be further edited. It is therefore convenient to convert them to static copies of the original components .

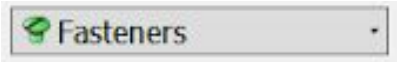
   a) Import the main support body

   From within the model tree, go to File > Import. Select the body (pieza_ejercicioAB.step). You can also use the add component tool  .

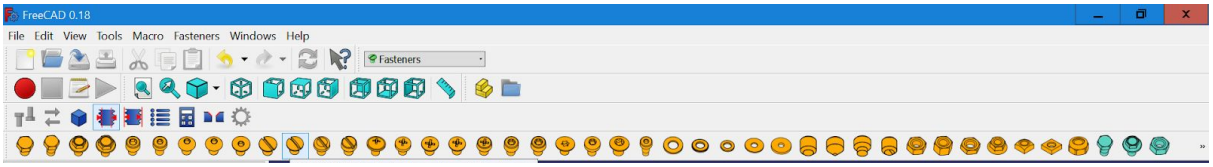
   b) Import the amplifier:

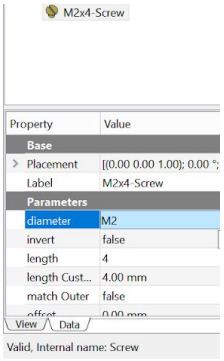
   From within the model tree, go to File > Import. Select the body (Amplificador.step). You can also use the add component tool  .

c) Insert a screw:

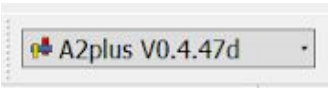
Go to the Fasteners workbench 

Select a screw. It will appear at the origin and you might not be able to see it through the main body.



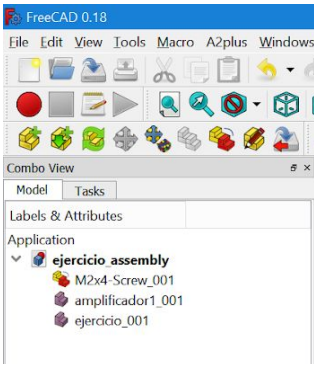
Edit its properties so it has an M2 diameter and 4mm length. 

To change a component's visibility, select it in the model tree, right click and choose "Toggle visibility", or press the spacebar.

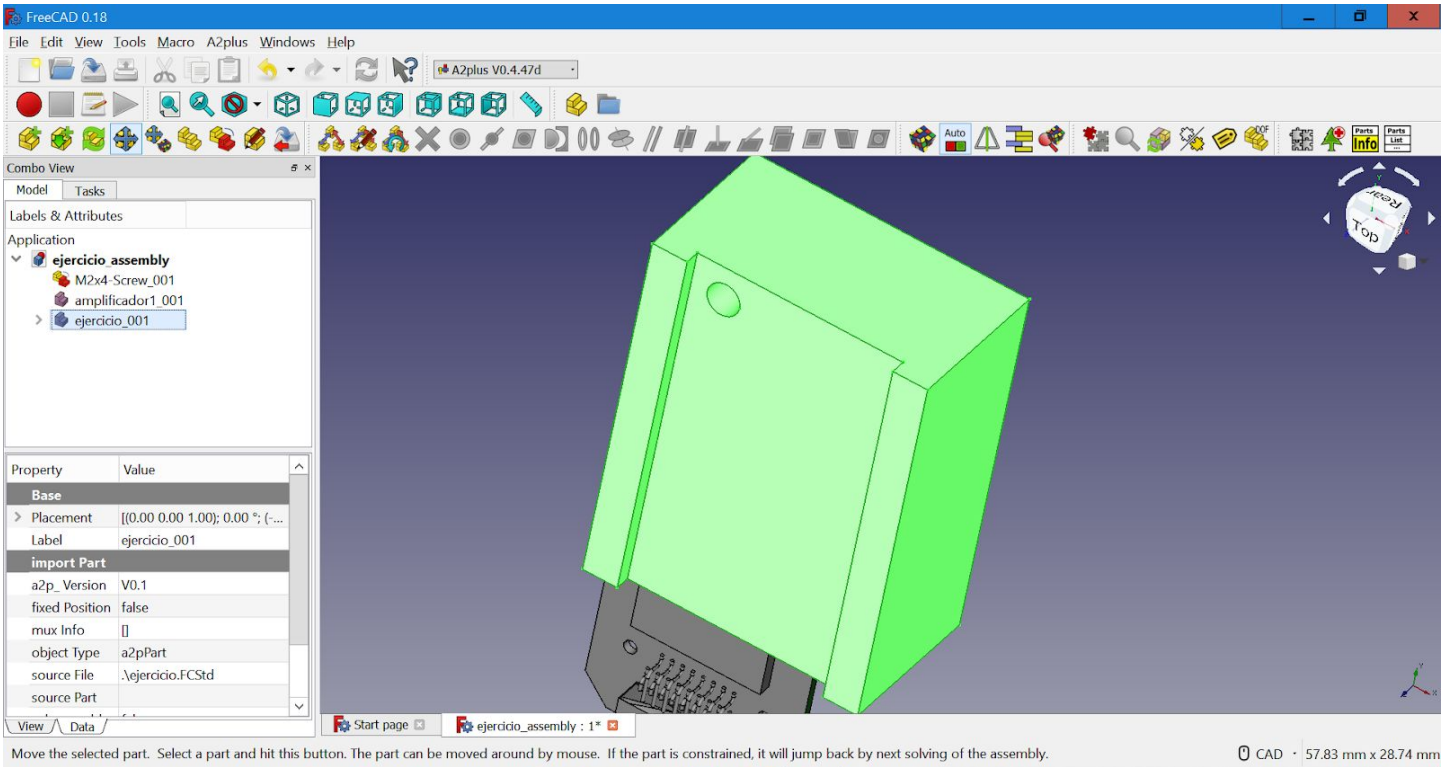
3. Go to the assembly workbench A2Plus to align the components 

.

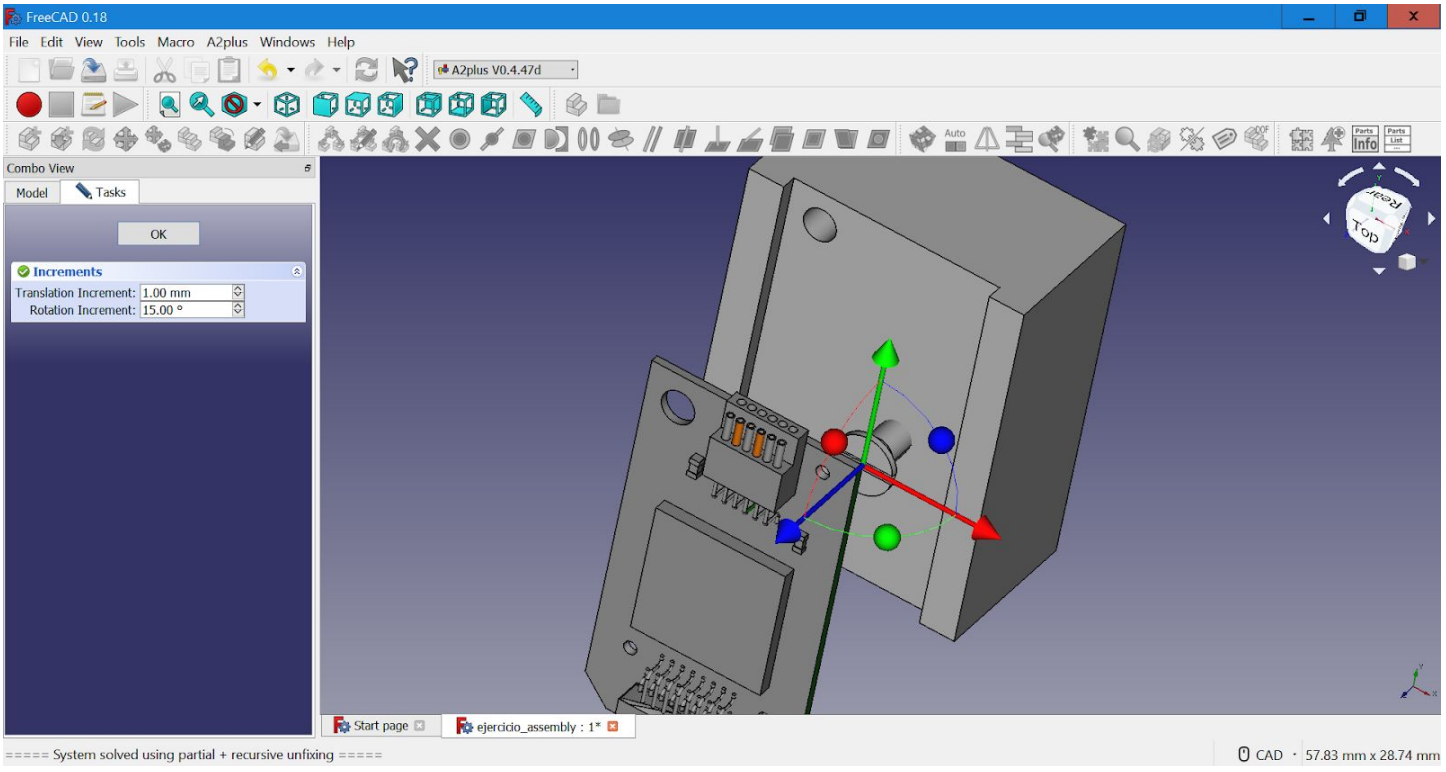
4. Select the screw and convert it to a static component with the convert part tool 
.

This changes its icon 

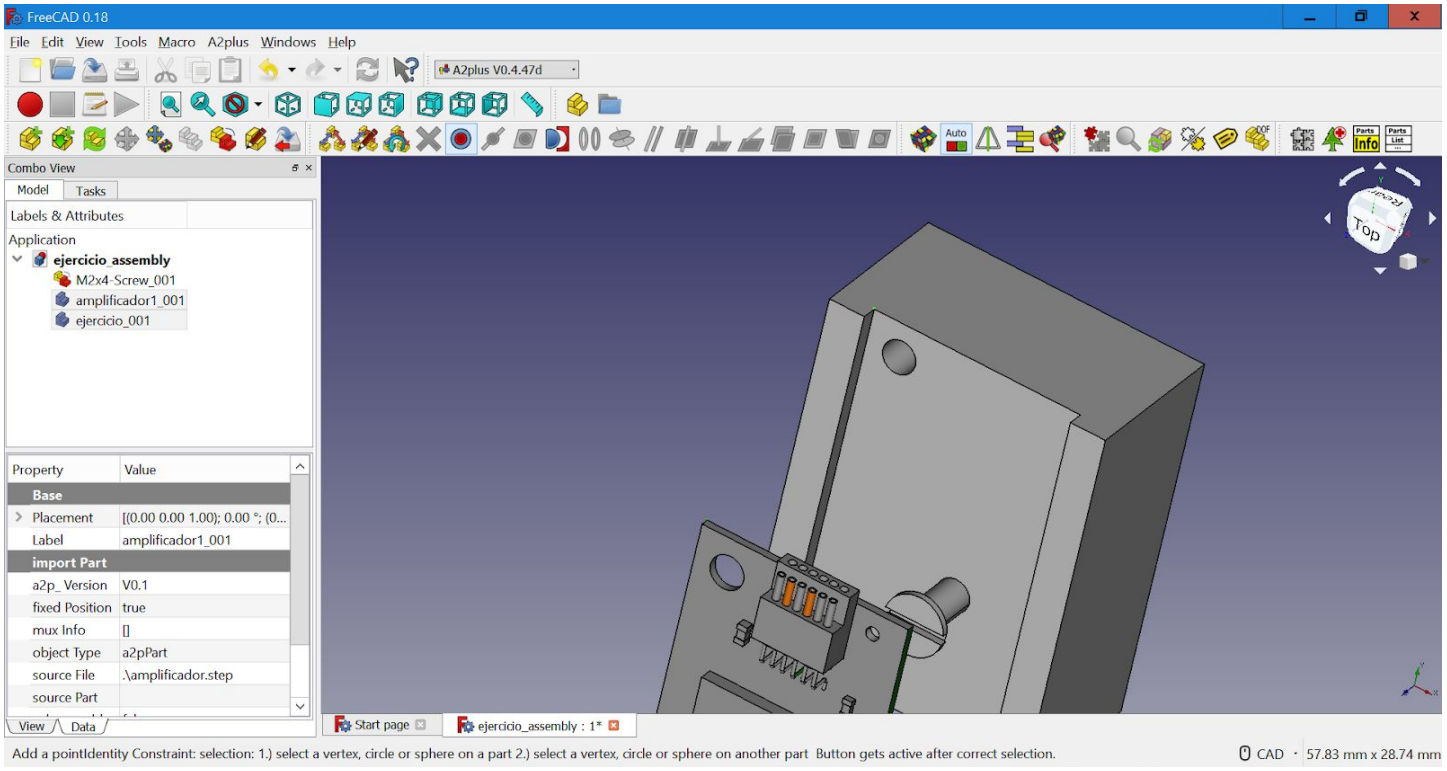
5. Move the components so you can see the vertices you want to align. To do that, select each component in the model tree and use the move tool  to change their position.



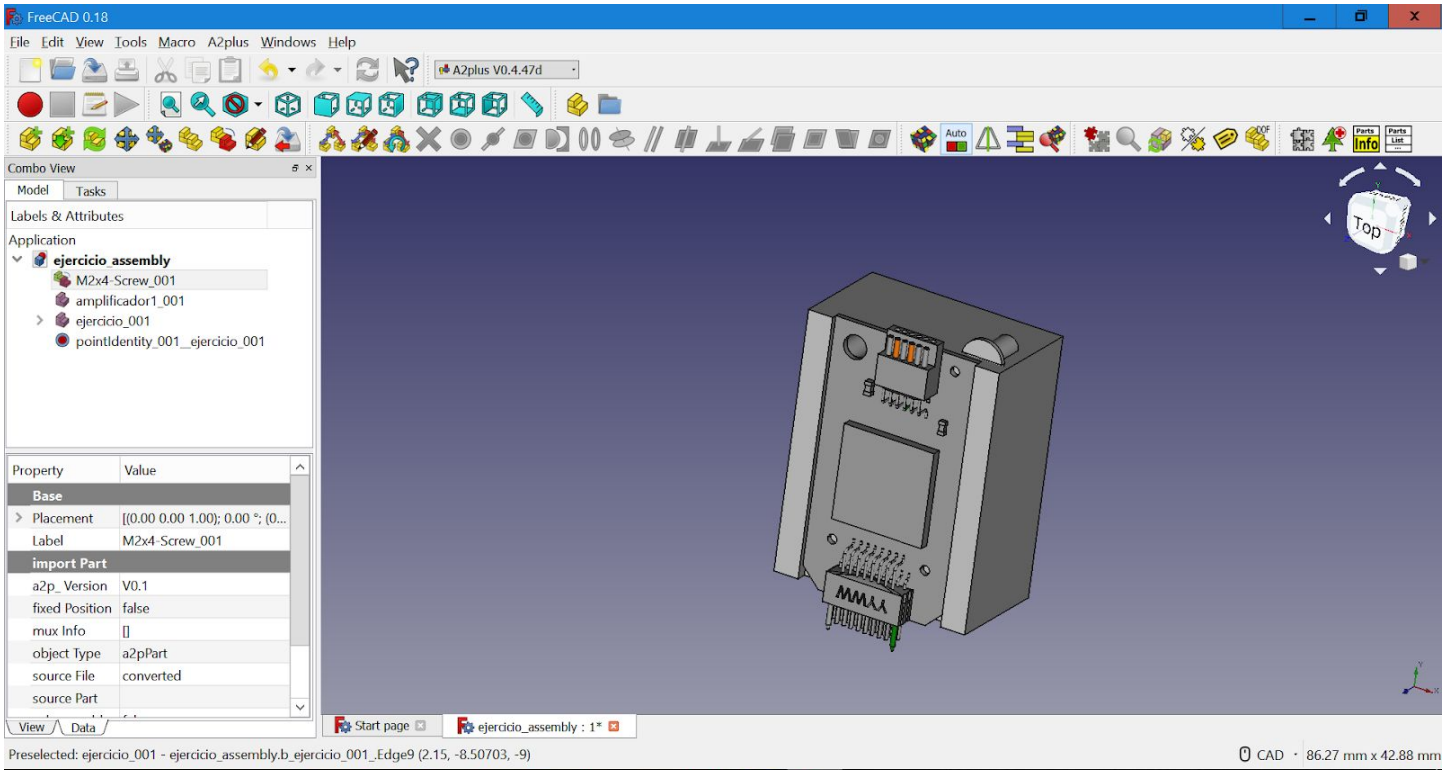
These arrows appear and clicking them will enable us to drag the components to a new position. We need to be able to see and select the top edge of the amplifier.



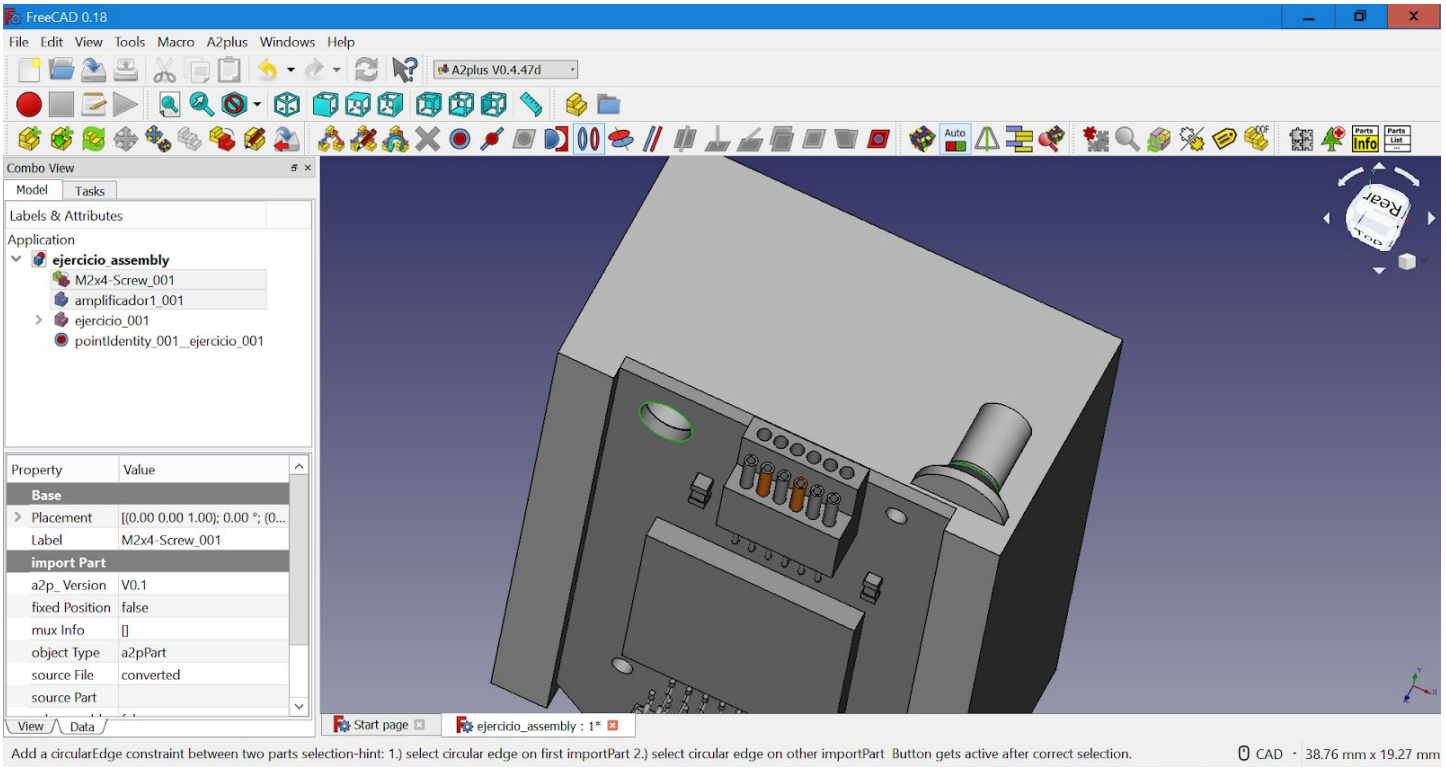
6. Hold down the Ctrl key to select the two vertices we want to align and use the coincident point constraint  .


FreeCAD 0.18
File Edit View Tools Macro A2plus Windows Help
A2plus V0.4.47d
Combo View
Model Tasks
Labels & Attributes
Application
ejercicio_assembly
M2x4-Screw_001
amplificador1_001
ejercicio_001
Property Value
Base
Placement [(0.00 0.00 1.00); 0.00 °; (0...
Label amplificador1_001
import Part
a2p_ Version V0.1
fixed Position true
mux Info []
object Type a2pPart
source File .\amplificador.step
source Part
View Data
Start page
ejercicio_assembly : 1*
Top
Add a pointIdentity Constraint: selection: 1.) select a vertex, circle or sphere on a part 2.) select a vertex, circle or sphere on another part Button gets active after correct selection.
CAD 57.83 mm x 28.74 mm

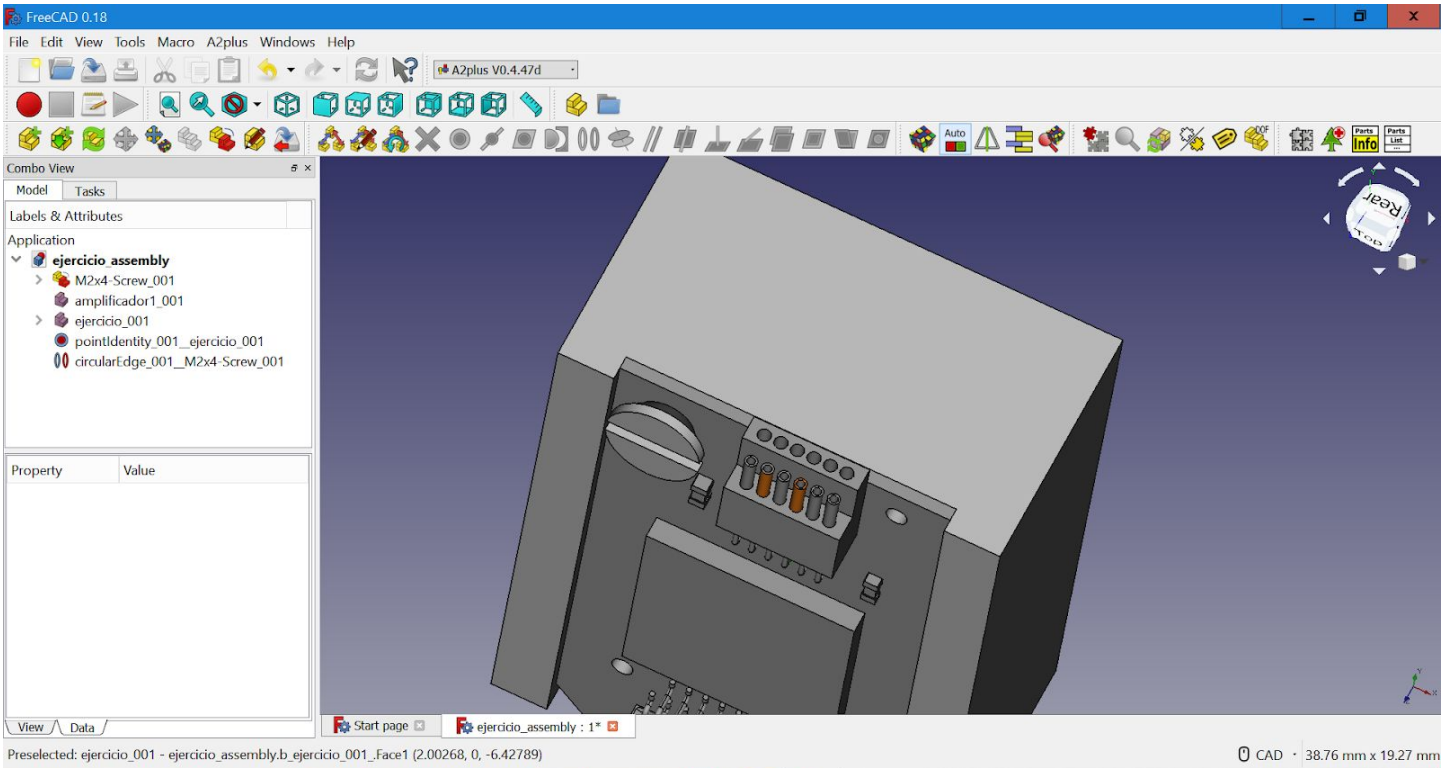
Result:


FreeCAD 0.18
File Edit View Tools Macro A2plus Windows Help
A2plus V0.4.47d
Combo View
Model Tasks
Labels & Attributes
Application
ejercicio_assembly
M2x4-Screw_001
amplificador1_001
ejercicio_001
pointIdentity_001_ejercicio_001
Property Value
Base
Placement [(0.00 0.00 1.00); 0.00 °; (0...
Label M2x4-Screw_001
import Part
a2p_ Version V0.1
fixed Position false
mux Info []
object Type a2pPart
source File converted
source Part
View Data
Start page
ejercicio_assembly : 1*
Top
Preselected: ejercicio_001 - ejercicio_assembly.b_ejercicio_001_.Edge9 (2.15, -8.50703, -9)
CAD 86.27 mm x 42.88 mm

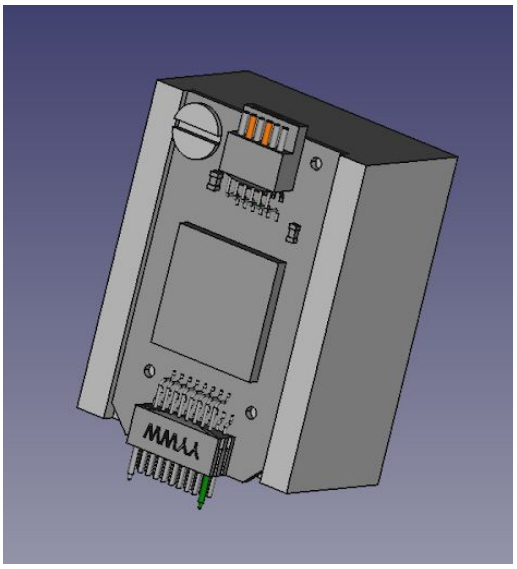
7. Hold down the Ctrl key and select the circular border between the screw head and body, and the circular edge of the hole on the amplifier board. Use the coincident circular edge constraint  .



Result:



Done, congratulations! You assembled components so you can see they can come together properly, make a nice informative render to show off and iterate your design.



Other tools I used for the presentation:
Technical drawing with the “TechDraw” workbench and an animation with the “Exploded Assembly” workbench, after installing that addon. There are tutorials online about these tools.