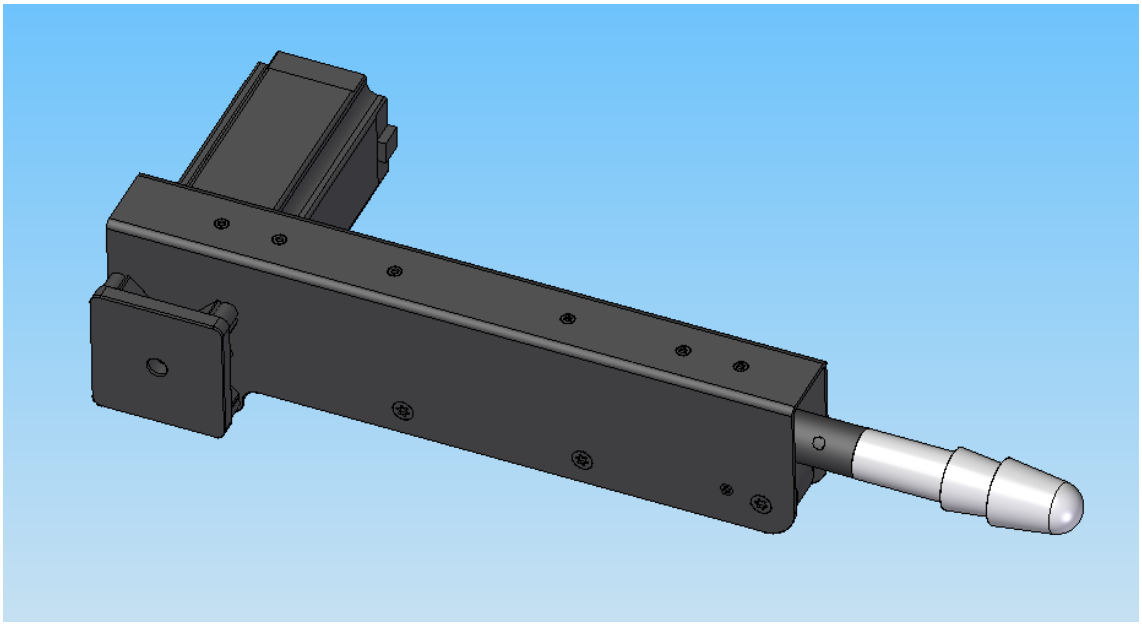
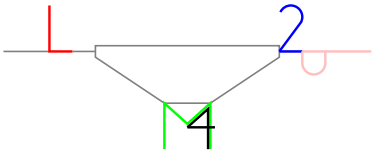
LM42P

Love(L) Machine(M) For(4) Two(2) People(P)



by an anonymous author

An open source document presenting
the LM42P



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Contents

Part I

DIY

Here you can find informations about how to get a **LM42P**. Actually, there are two variants available either :

- **m1** ;
- **m2**.

Here is some information that is good to know before starting to build your machine.

- For the 3D-printed parts, all files are located in the directory named `3d-print-files`, which is inside the parent directory named after the corresponding part.
- All part names are marked in **bold**.
- Apply threadlock to the screws.

Chapter 1

m2

1.1 housing

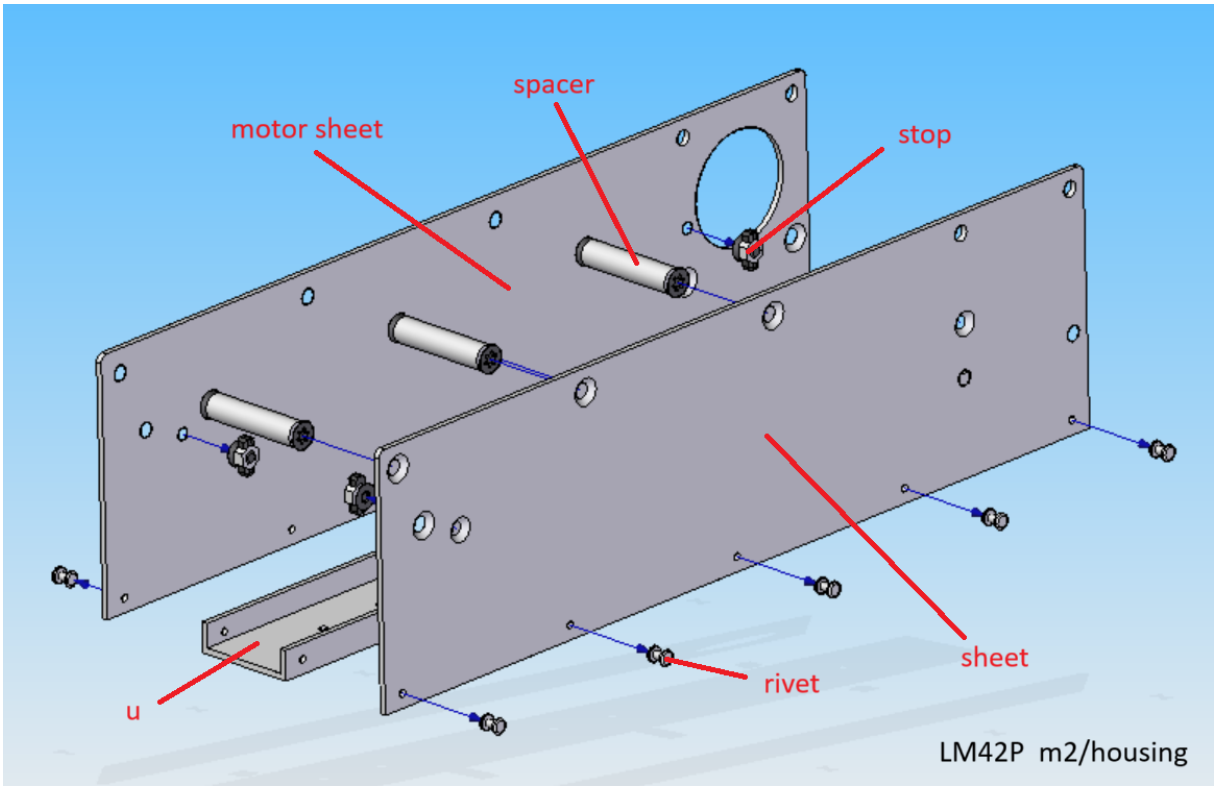


Figure 1.1: m2 housing parts

1.1.1 Parts list

Table 1.1: Parts list of housing

Qty	Part	Description	Material
1	u	10x35x250	aluminium
1	sheet	86x305x2	aluminium
1	motor sheet	86x305x2	aluminium
4	stop	13.7x33x4	aluminium
3	spacer	see section spacer	-
10	rivet	2.4 x 8 mm	aluminium

1.1.2 sheet

This section describes the manufacturing process for the part called **sheet**.

Drawing

See Figure 1.2, page 10.

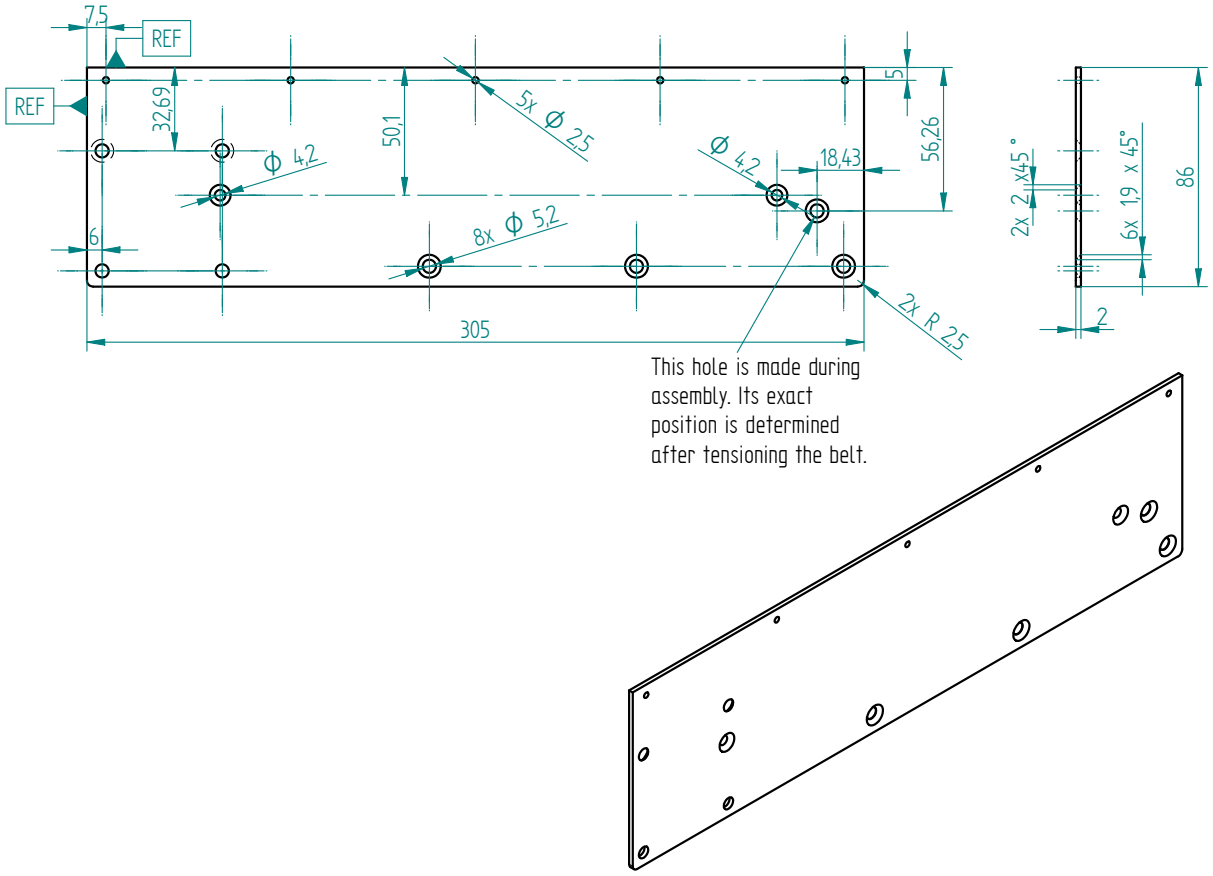


Figure 1.2: Drawing of the **sheet** part

Required Tools and Components

Below is the list of materials required to produce the part named **sheet**.

- 1x sheet dimensions : 86x305x2 material : aluminium ;
- 1x **steel rule** ;
- 1x **file** ;
- 1x **drillator** see section drillator 1.1.5, p. 17 ;
- 1x **drillator-m** see section drillator-m 1.1.6, p. 19 ;
- 4x **clamp** ;
- 2x **2.5 mm drill bit** ;
- 1x **4.2 mm drill bit** ;
- 1x **5.2 mm drill bit** ;
- 1x **chamfering tool** ;
- 1x **drill press**.

Manufacturing Instructions

1. use a **file** to remove all sharp edges ;
2. carefully determine which face requires protection before proceeding ;
3. align and clamp the **drillator-m**, using the top-left corner as a reference, this is important for proper alignment ;
4. center punch all holes using a **2.5 mm drill bit** ;
5. remove the **drillator-m** ;
6. using the same drill bit, drill the two holes positioned at the far-left edge, one at the uppermost and one at the lowermost position ;
7. using two **2.5 mm drill bits**, align and clamp the **drillator** ;
8. center punch all holes ;
9. remove the **drillator** ;
10. drill all holes ;
11. chamfer all holes (use a screw to check the chamfer depth) ;
12. use a **file** to create both R 2.5 mm radii ;
13. remove the protective film or masking.

1.1.3 motor-sheet

This section describes the manufacturing process for the part called **motor-sheet**.

Drawing

See Figure 1.3, page 12.

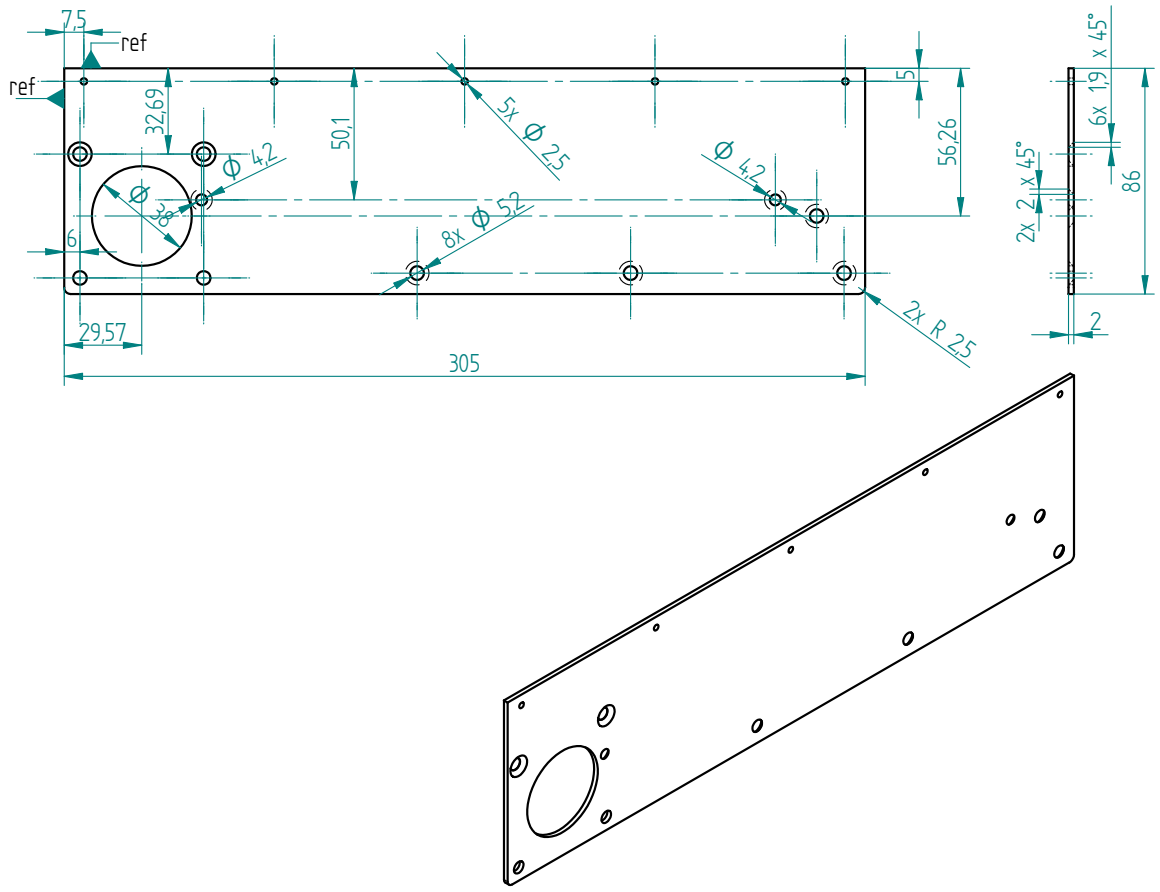


Figure 1.3: Drawing of the **motor-sheet** part

Required Tools and Components

Below is the list of materials required to produce the part named **motor-sheet**.

- 1x sheet dimensions : 86x305x2 material : aluminium ;
- 1x **flat/convex file** ;
- 1x **drillator** see section drillator 1.1.5, p. 17 ;
- 1x **drillator-m** see section drillator-m 1.1.6, p. 19 ;
- 1x **scribe** ;
- 4x **clamp** ;
- 2x **2.5 mm drill bit** ;
- 1x **4.2 mm drill bit** ;

- 1x **5.2 mm drill bit** ;
- 1x **jigsaw** ;
- 1x **chamfering tool** ;
- 1x **drill press**.

Manufacturing Instructions

1. use a **file** to remove all sharp edges ;
2. carefully determine which face requires protection before proceeding ;
3. align and clamp the **drillator-m**, using the top-left corner as a reference, this is important for proper alignment ;
4. using a **scriber**, mark the outline of the 38 mm diameter hole ;
5. center punch all holes using a **2.5 mm drill bit** ;
6. remove the **drillator-m** ;
7. using the same drill bit, drill the two holes positioned at the far-left edge, one at the uppermost and one at the lowermost position ;
8. using two **2.5 mm drill bits**, align and clamp the **drillator** ;
9. center punch all holes ;
10. remove the **drillator** ;
11. drill all holes ;
12. chamfer all holes (use a screw to check the chamfer depth) ;
13. use a **file** to create both R 2.5 mm radii ;
14. using a **jigsaw**, cut as close as possible to the 38 mm diameter outline ;
15. Using a **flat/convex file**, file the 38 mm hole until the motor fits through ;
16. remove the protective film or masking.

1.1.4 u

This section describes the manufacturing process for the part called **u**.

Drawing

See Figure 1.4, page 14.

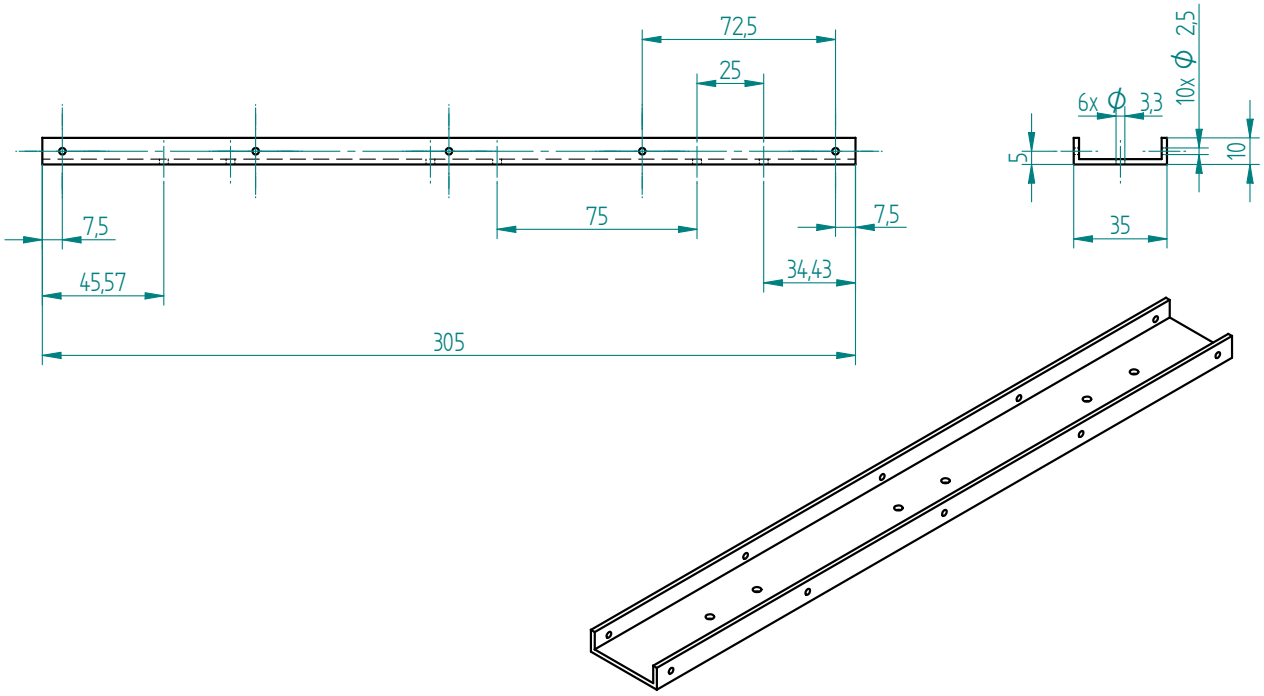


Figure 1.4: Drawing of the **u** part

Required Tools and Components

Below is the list of materials required to produce the part named **u**.

- 1x **square tube** dimension : 35x35x2x305 material : aluminium ;
- 1x **gauge** minimum length: 305 mm ;
- 1x **try square** ;
- 1x **steel rule** ;
- 1x **scriber** ;
- 1x **hand saw** ;
- 1x **perpendicaltor** ;
- 1x **file** ;
- 1x **rail** (see section **linear-guide** 1.2, p. 23) ;
- 2x **clamp** ;
- 1x **3.5 mm drill bit** ;
- 1x **3.3 mm drill bit** ;
- 1x **2.5 mm drill bit** ;
- 1x **chamfering tool** ;
- 1x **drill press**.

Manufacturing Instructions

1. scribe a line with a **scriber**, leaving approximately 0.3 mm of extra material beyond the final total length ;
2. cut the **square tube** to length using a **handsaw** and a **try square** ;
3. use the **perpendiculator** to ensure both ends are square ;
4. scribe two lines using the **scriber**, each about 0.3 mm from the edge of the squared **square tube** ;
5. cut the **square tube** along the scribed lines using the **handsaw** ;
6. use a **file** to clean the cuts and chamfer the edges ;
7. clamp the **rail** in the correct position using a **gauge** (make sure it's centered), see Figure 1.5, page 16 ;

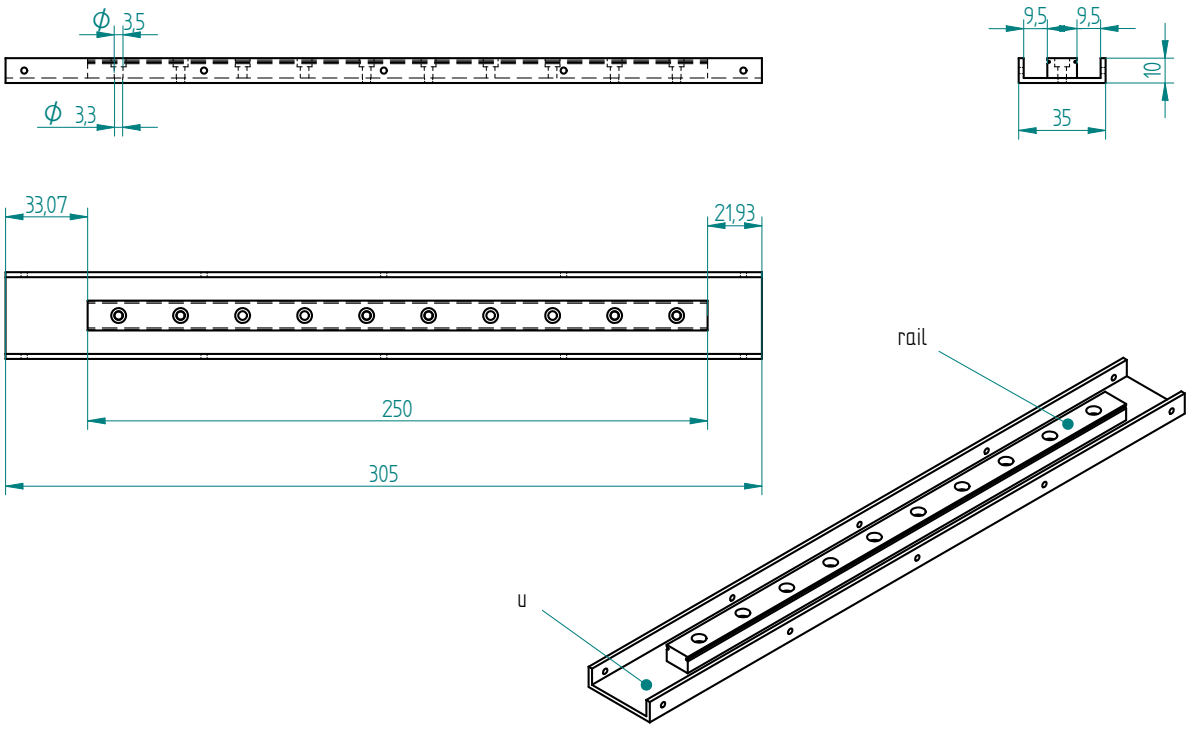


Figure 1.5: Center punch the 3.3 mm hole through the **rail** using a **3.5 mm drill bit**

8. mark the positions of the six 3.3 mm holes using a **3.5 mm drill bit** to center punch ;
9. drill the six holes using a **3.3 mm drill bit** (do not drill the 2.5 mm holes yet—those will be drilled with the sheets) ;
10. chamfer the six holes using a **chamfering tool** ;
11. clamp the **sheet** in place ;
12. center punch the five holes using a **2.5 mm drill bit** ;
13. clamp the **motor sheet** ;
14. center punch the five holes using a **2.5 mm drill bit** ;
15. drill all ten holes using a **2.5 mm drill bit** ;
16. chamfer the six holes using a **chamfering tool**.

1.1.5 drillator

This section describes the manufacturing process for the part called **drillator**.

Remark : If your 3D printer has a large enough build volume, you can print the **drillator** and **drillator-m** in one piece, which improves alignment accuracy.

Drawing

See Figure 1.6, page 18.

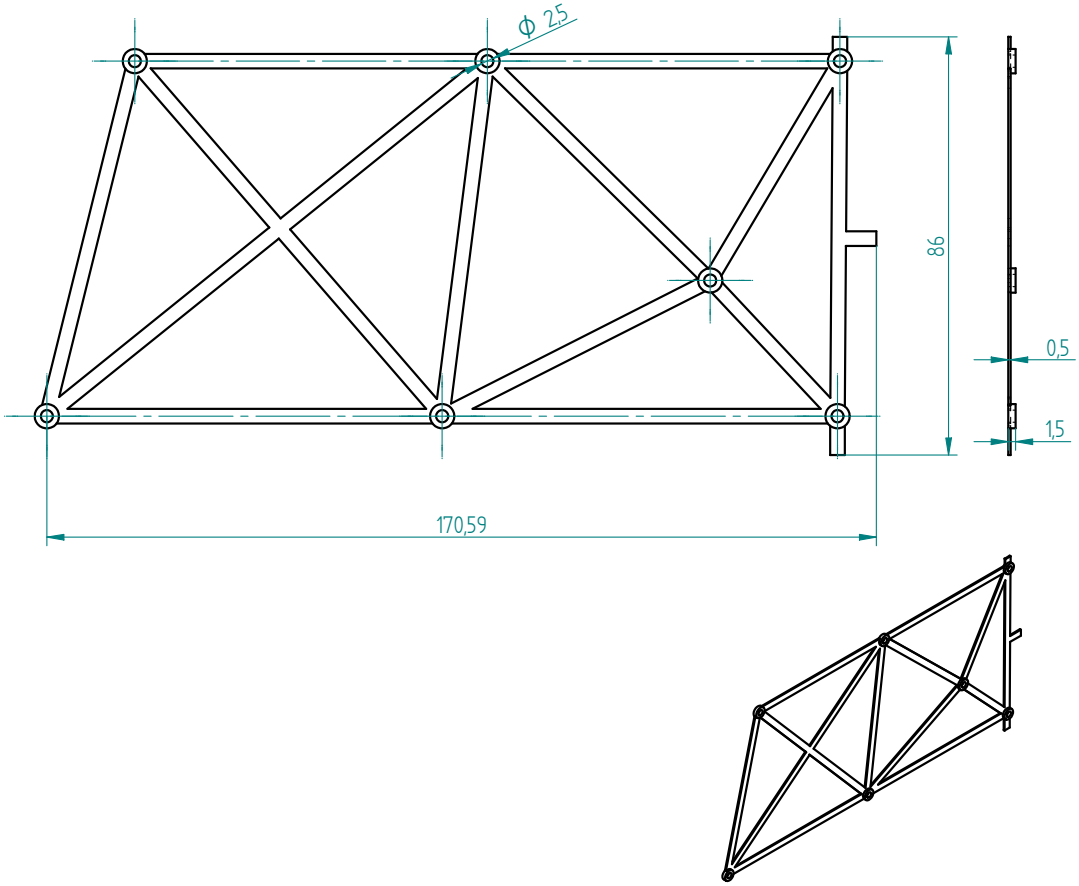


Figure 1.6: Drawing of the **drillator** part

Required Tools and Components

Below is the list of materials required to produce the part named **drillator**.

- 1x **3d printer** ;
- 1x **PLA** ;
- 1x **file** ;
- 1x **drill** ;
- 1x **2.5 mm drill bit**.

Manufacturing Instructions

1. 3D print the part using the files located in the `3d-print-files` directory ;
2. chamfer the edges using a **file** ;
3. drill the 2.5 mm holes using a **2.5 mm drill bit** and a **drill**.

1.1.6 drillator-m

Remark : If your 3D printer has a large enough build volume, you can print the **drillator** and **drillator-m** in one piece, which improves alignment accuracy.

Drawing

See Figure 1.7, page 20.

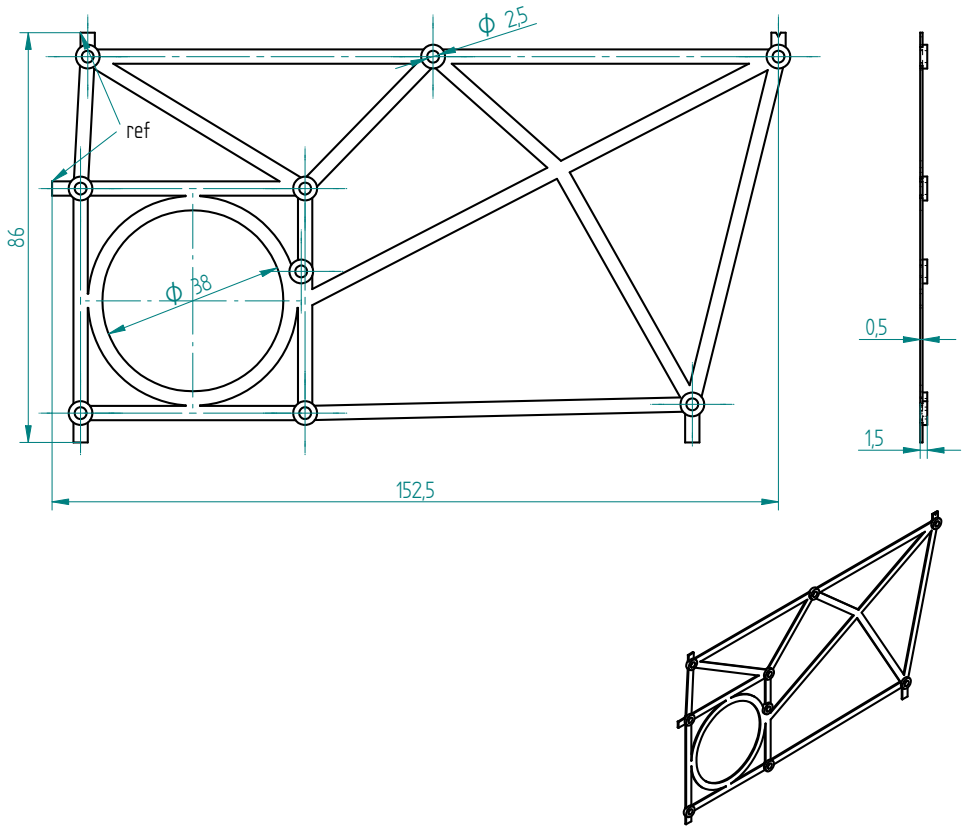


Figure 1.7: Drawing of the **drillator-m**

Required Tools and Components

Below is the list of materials required to produce the part named **drillator**.

- 1x **3d printer** ;
- 1x **PLA** ;
- 1x **file** ;
- 1x **drill** ;
- 1x **2.5 mm drill bit**.

Manufacturing Instructions

1. 3D print the part using the files located in the `3d-print-files` directory ;
2. chamfer the edges using a **file** ;
3. drill the 2.5 mm holes using a **2.5 mm drill bit** and a **drill**.

1.1.7 stop

Drawing

See Figure 1.8, page 21.

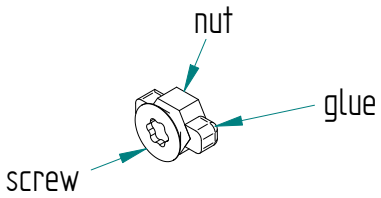


Figure 1.8: Drawing of the **stop**

Parts list

Table 1.2: Parts list of housing/stop

quantity	name	specification	material
`4x1=4`	**screw**	M4 × 6 mm Torx flat head screw	stainless steel
`4x1=4`	**nut**	standard M4 hex nut	stainless steel
`-`	**glue**	black	Poliflex 444

1.1.8 spacer

Drawing

See Figure 1.9, page 22.

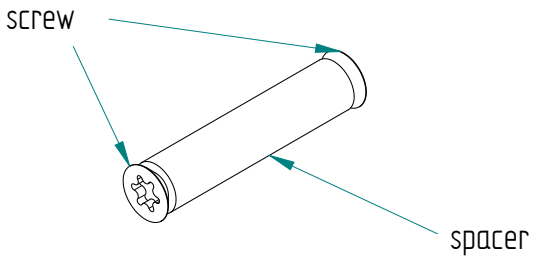


Figure 1.9: Drawing of the **spacer**

Parts list

Table 1.3: Parts list of housing/spacer

Qty	Part	Description	Material
3x2=6	**screw**	M5 × 12 mm Torx flat head screw	stainless steel
3x1=3	**spacer**	M5 x 8 x 35 mm	aluminium

1.2 linear guide

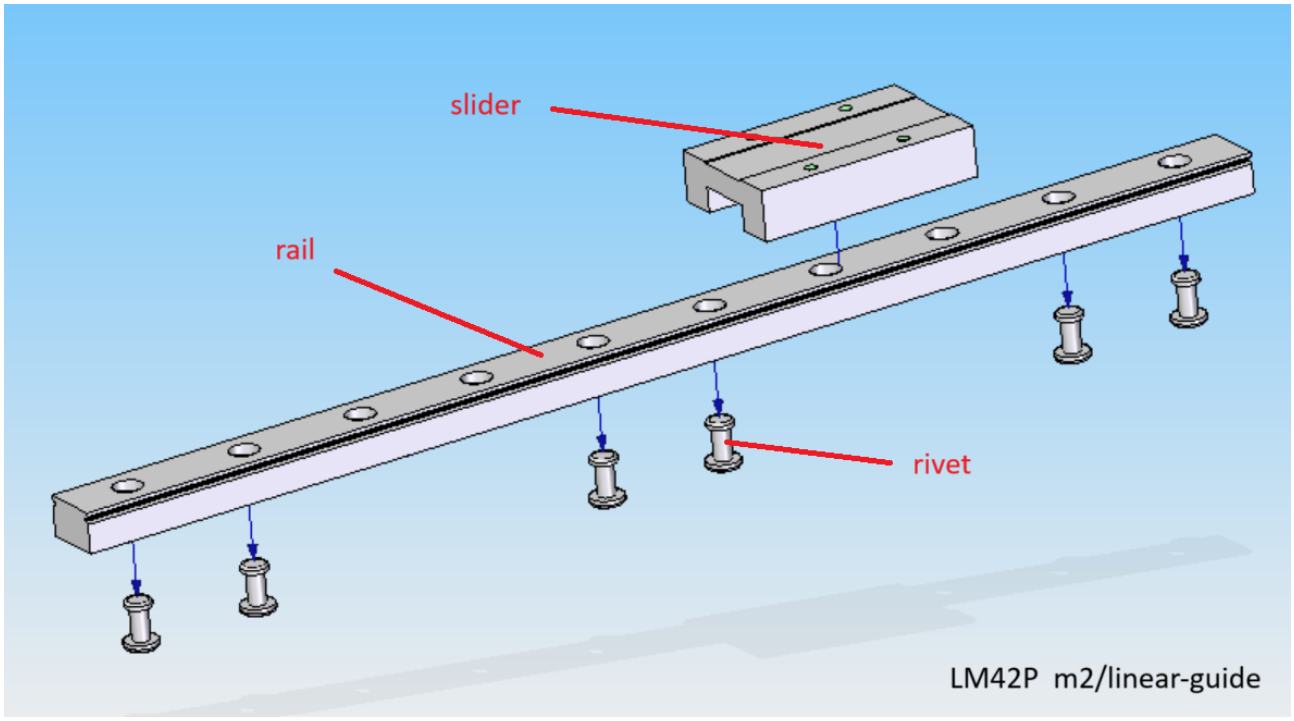


Figure 1.10: m2 linear guide parts

1.2.1 Parts list

Table 1.4: Parts list of **linear guide**

Qty	Part	Description	Material
1	rail	MGN12H, length: 250 mm	-
1	slider	MGN12H, 27 x 45.4 mm	-
6	rivet	3.2 x 10 mm	aluminium

1.2.2 Drawing

See Figure 1.11, page 24.

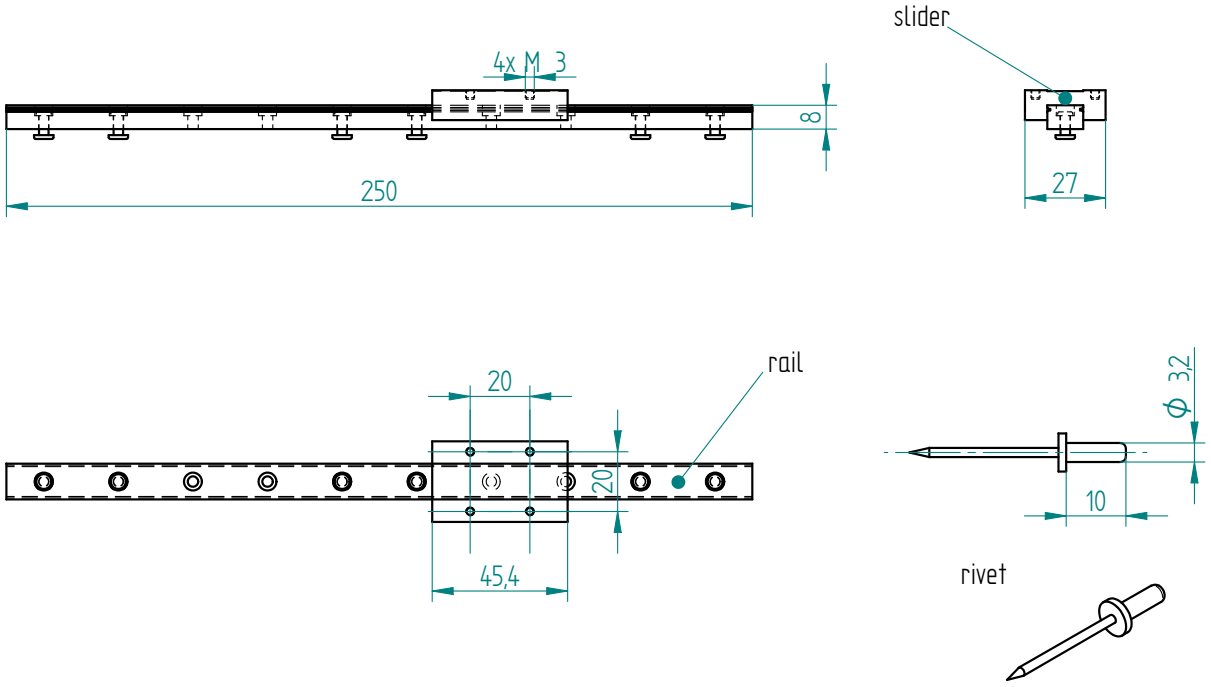


Figure 1.11: Drawing of the linear guide parts

1.3 block

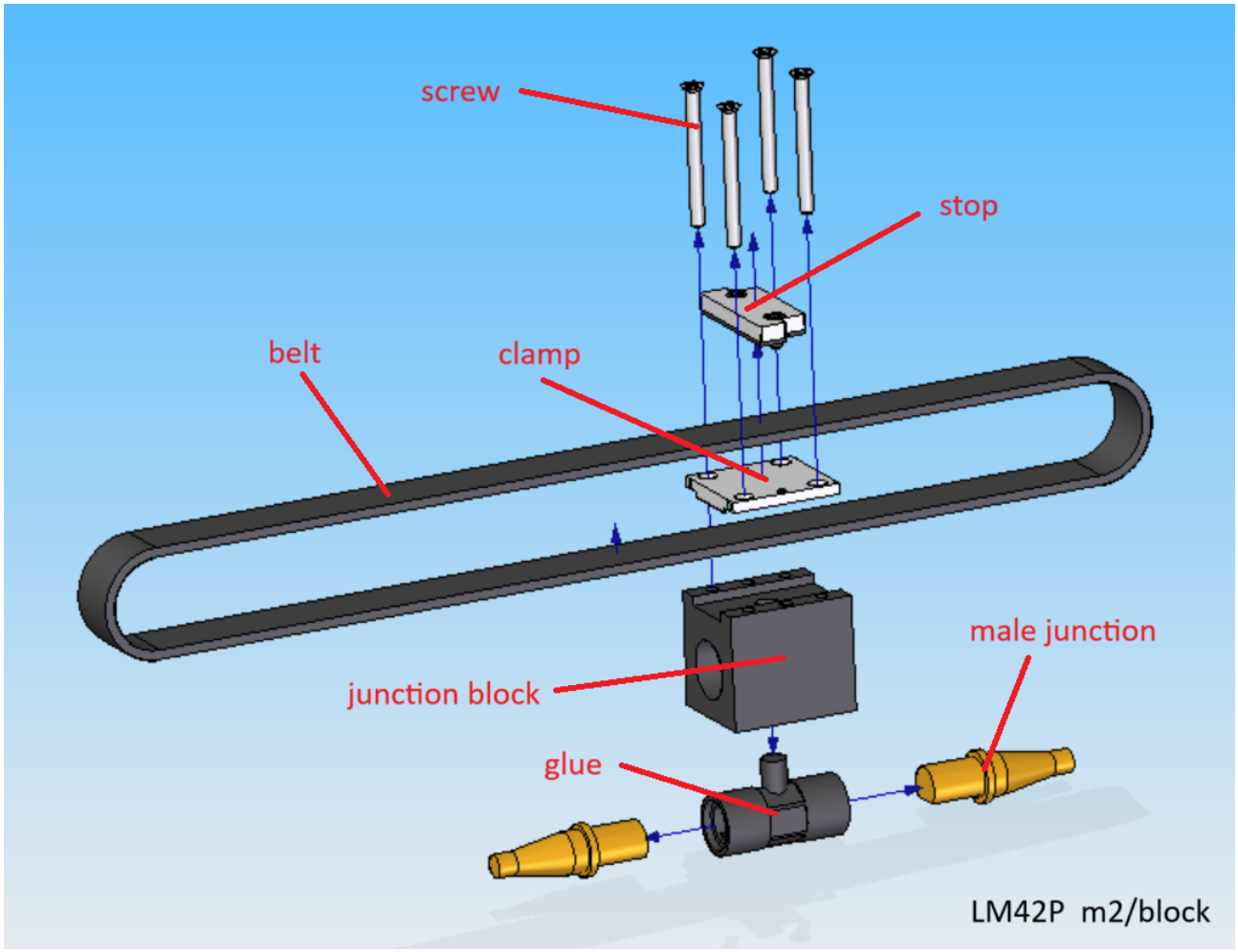


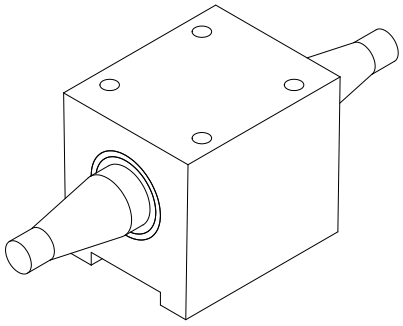
Figure 1.12: m2 block parts

1.3.1 Parts list

Table 1.5: Parts list of **block**

Qty	Part	Description	Material
1	junction block	3D printed	nylon
1	glue	casted	epoxy
2	male junction	google : `pool cue junction`	brass
1	belt	HTD 3	-
1	clamp	HTD 3	aluminium
1	stop	subassemblie (see section)	see section **stop**
4	screw	M3 × 36 mm flat head screw	stainless steel

1.3.2 junction block



Drawing

See Figure 1.13, page 27.

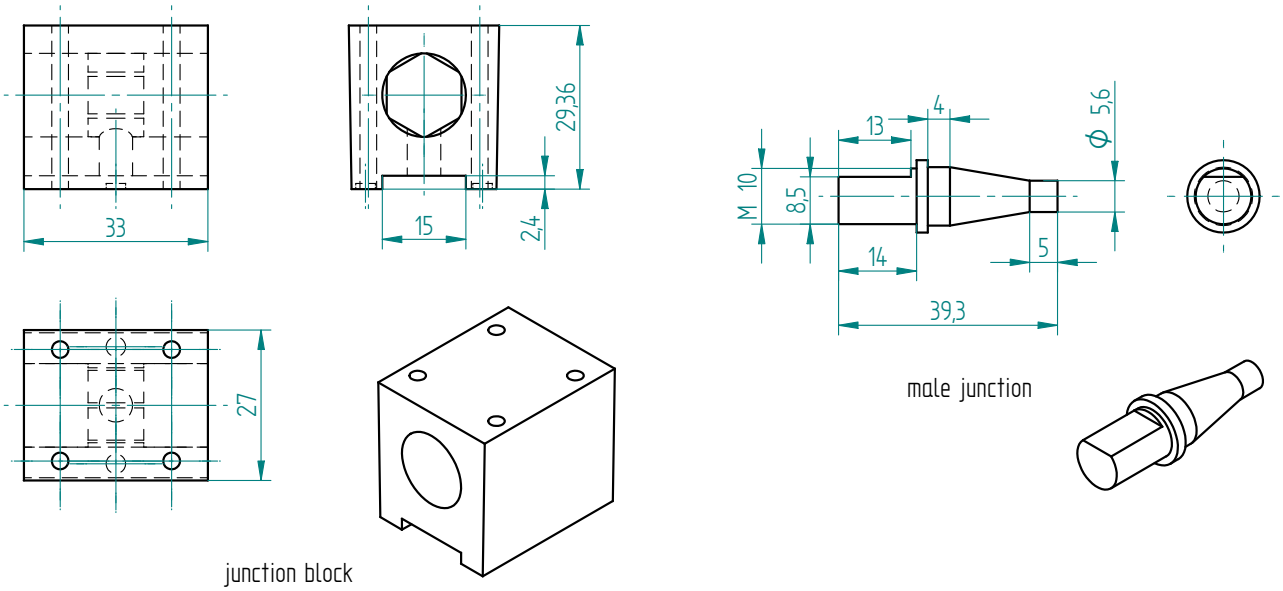


Figure 1.13: Drawing of the junction block parts

Required Tools and Components

- 1x 3D printer ;
- 1x nylon filament ;
- 1x STL file ;
- 2x male junction ;
- 1x file ;
- 1x gauge ;
- 4x screw (M3, length=36mm) ;
- 1x alignator ;
- 1x glue ;
- 2x rods ;
- 2x elastic ;
- 1x hot glue.

Manufacturing Instructions

1. 3D print the **junction block** using the STL file and nylon filament.
2. File a flat surface of 8.5 x 13 mm on the threaded M10 part (on both **junction block**.
3. Mount the **junction block** on the **alignator** (**slider**) with the **spacer** and the four **screw-3x**.
4. Insert a **male junction** on each end of the **rod**.
5. Place the **slider** on the **rail** and both **rods** on the **v**.
6. Attach using two **elastic** bands.
7. Press the **rods** against the **junction block**.
8. Fix them in place with **hot glue**. See Figure 1.14, page 29 and Figure 1.15, page 29.

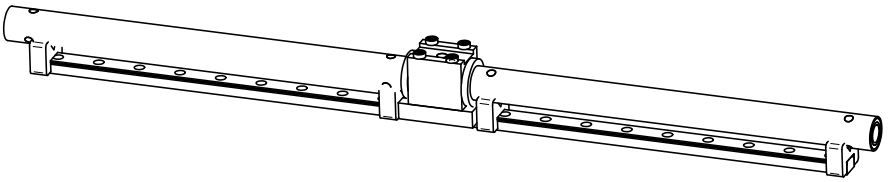


Figure 1.14: male junction aligning

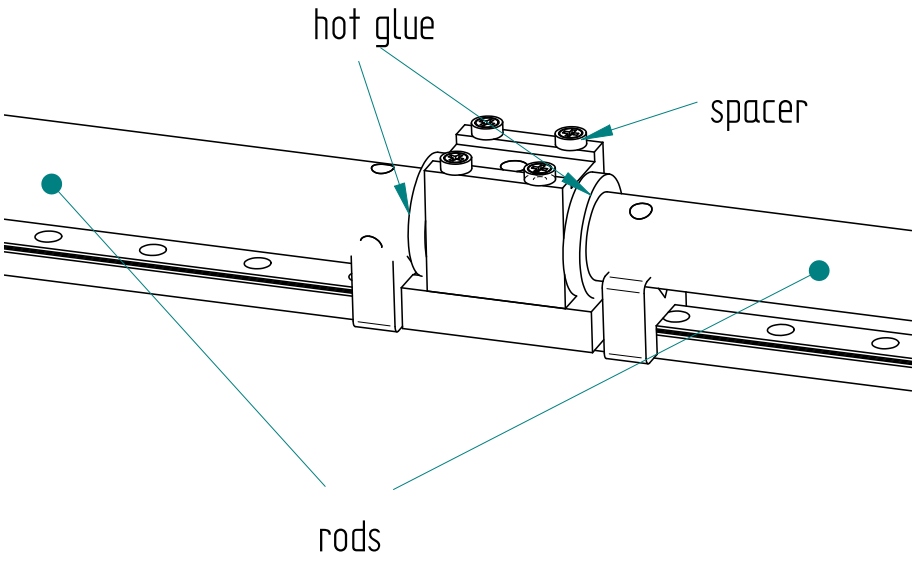


Figure 1.15: male junction aligning zoomed

9. Test the seal by blowing into the hole of the **junction block**.
10. Prepare the **glue**[1]:
    (a) Quantity **hardener**: 2 g ;
    (b) Quantity **resin**: 5 g ;
    (c) Quantity **graphite powder**: 1.5 g.
11. Pour the mixture into the **junction block**.
12. Cure for 24 hours at 20°C or 4 hours at 40°C.
13. Remove the **hot glue**.
14. Remove the four **screw-3x** and the **spacer**.

[1]Adjust the quantity of **resin** and **hardener** according to the type of glue used.

1.3.3 belt

Drawing

See Figure 1.16, page 31.

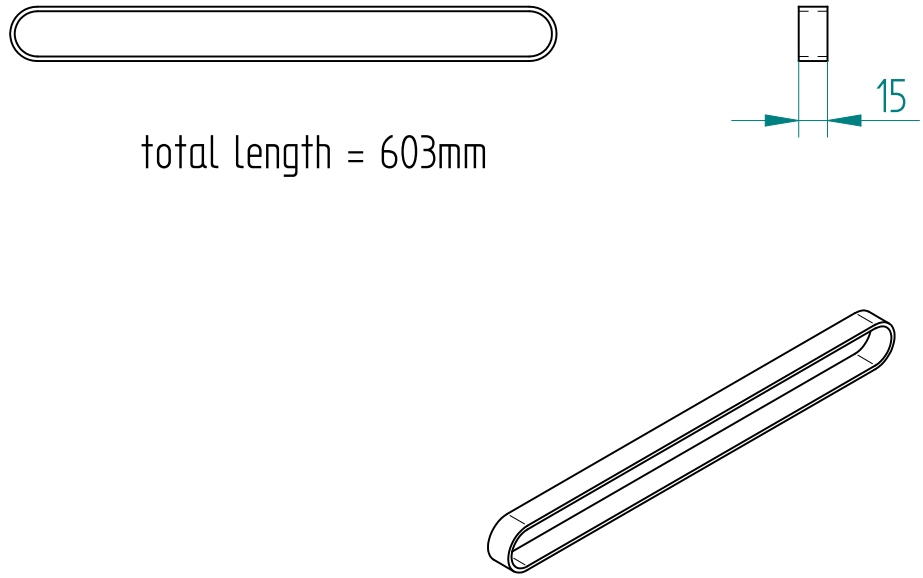


Figure 1.16: Drawing of the belt

Required Tools and Components

- 1x roll of belt standard HTD-5M ;
- 1x double meter ;
- 1x scissors.

Manufacturing Instructions

1. Cut a **belt** with a length of 603 mm .

1.3.4 clamp

Drawing

See Figure 1.17, page 32.

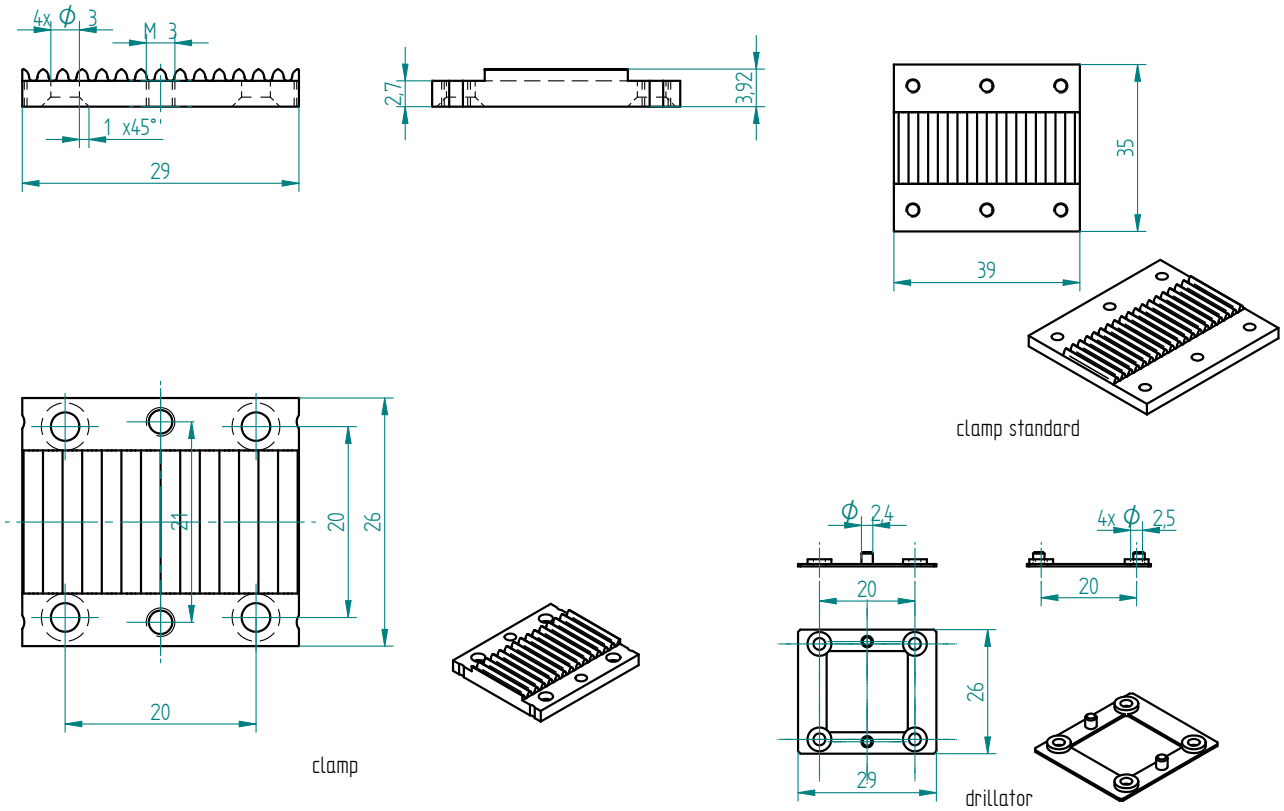


Figure 1.17: Drawing of the clamp

Required Tools and Components

- 1x clamp standard ;
- 1x 3D printer ;
- 1x PLA filament ;
- 1x STL file ;
- 1x drillator ;
- 2x clamp ;
- 1x scriber ;
- 1x file ;

- 1x 2.5 mm drill bit ;
- 1x 3 mm drill bit ;
- 1x chamfer mill ;
- 1x driller ;
- 1x drill press ;
- 1x gauge.

Manufacturing Instructions

1. 3D print the **drillator** using the provided STL file and PLA filament.
2. Clamp the **drillator** onto the **clamp standard**.
3. Scribe the outer dimensions.
4. Center punch the four holes.
5. Mill or cut the shape to size using a **handsaw**, according to the **Drawing** section.
6. Chamfer all sharp edges.
7. Drill the four holes using a 3 mm drill bit.
8. Chamfer all four holes: $1 \times 45°$.

1.3.5 screw

These screws are used to assemble the **stop**, **belt**, **clamp**, and **junction block** onto the **slider**. Initially, the exact screw length cannot be determined. The objective is to ensure that the threaded portion engages as much as possible with the **slider**, so the **screw** holds securely.

Drawing

See Figure 1.18, page 34.

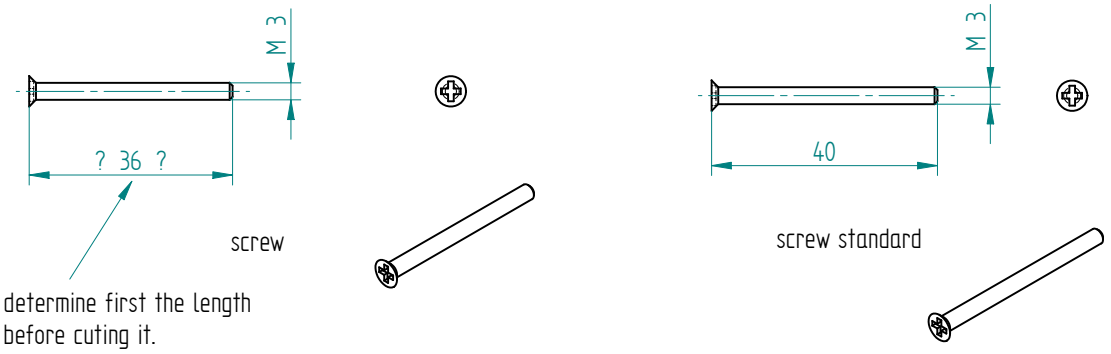


Figure 1.18: Drawing of the screw

Required Tools and Components

- 4x screw standard (M3, length = 40 mm) ;
- 1x **junction block** ;
- 1x **belt** ;
- 1x **clamp** ;
- 1x depth gauge ;
- 1x handsaw ;
- 1x file ;

- 1x gauge ;
- 1x Phillips screwdriver ;
- 1x bench vise.

Manufacturing Instructions

1. Place the **belt** between the **clamp** and the **junction block**.
2. Use a **screw-40** to loosely secure the **belt** and the **junction block** onto the **slider**.
   Tighten the screw until it reaches the end of the internal thread in the slider.
   Warning: It's normal if the ***junction block*** *is not fully tightened—this screw is slightly too long.*
3. Using a **depth gauge** or ruler, measure how much of the **screw** needs to be cut off.
4. Cut the **screw standard** to the correct length using a **handsaw**.
   Tip: Use a ***bench vise*** *to hold the screw steady while cutting.*
   Deburr the end with a ***file*** *for a clean finish.*
5. Based on the first test, the ideal screw length is approximately **36 mm**.

1.3.6 stop

Drawing

See Figure 1.19, page 36.

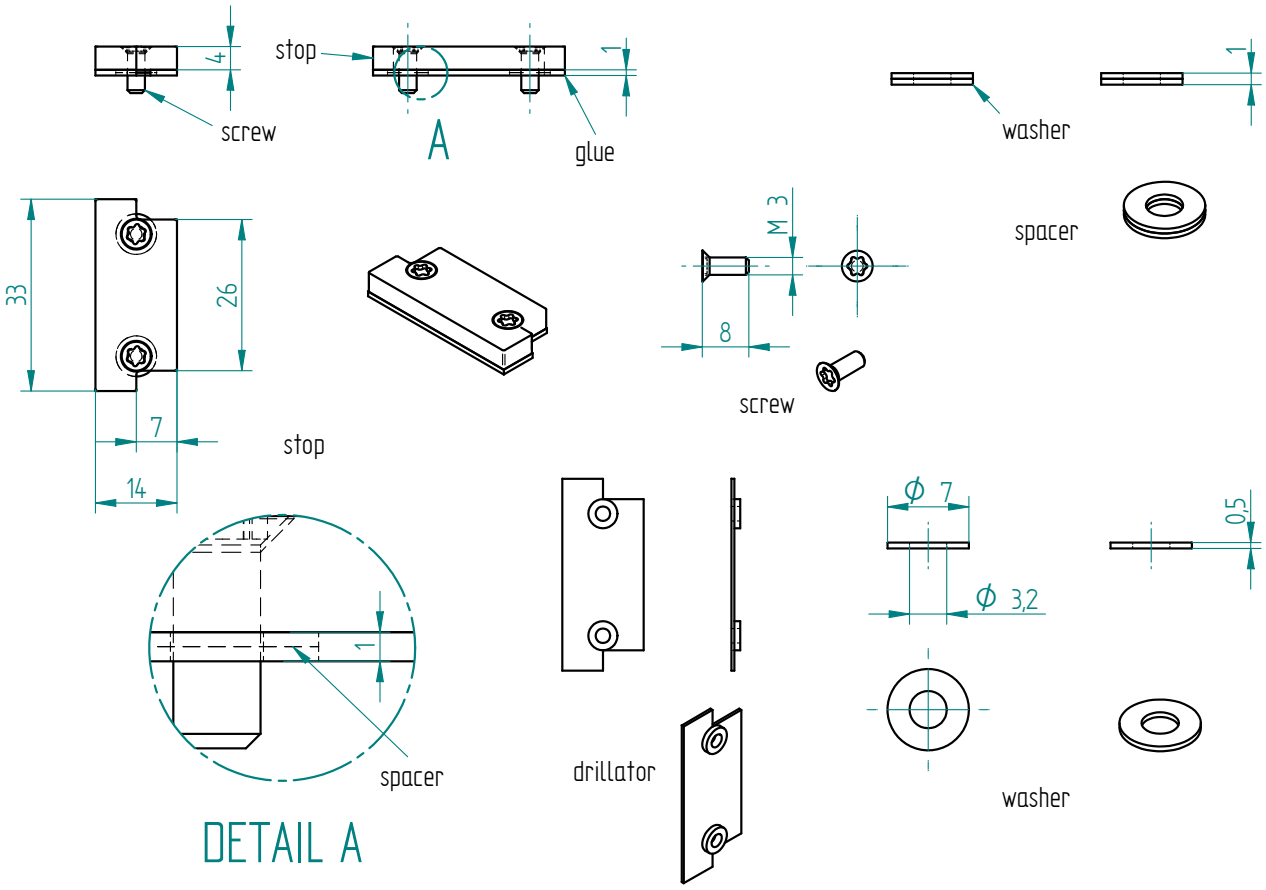


Figure 1.19: Drawing of the stop parts

Parts list

Table 1.6: Parts list of **block/stop**

quantity	name	specification	material
1	stop	14 x 4 x 33	aluminium
4	washer (2 spacer)	3.2 x 7 x 0.5	stainless steel
2	screw	M3 × 8 mm Torx flat head screw	stainless steel
1	glue	-	Poliflex 444

Required Tools and Components

- 1x 14 x 33 aluminium sheet thickness 4 mm ;
- 2x clamps ;

- 1x scriber ;
- 1x drillator ;
- 1x mill ;
- 1x file ;
- 1x 2.5 mm drill bit ;
- 1x 3 mm drill bit ;
- 1x chamfer mill ;
- 1x driller ;
- 1x drill press.

Manufacturing Instructions

1. Mill or file the **stop** (using the tool **drillator**) according to the dimensions shown in the **Drawing** ;
2. Using the shaped tool **drillator**, drill both holes ;
3. Drill and chamfer the two 3 mm holes .

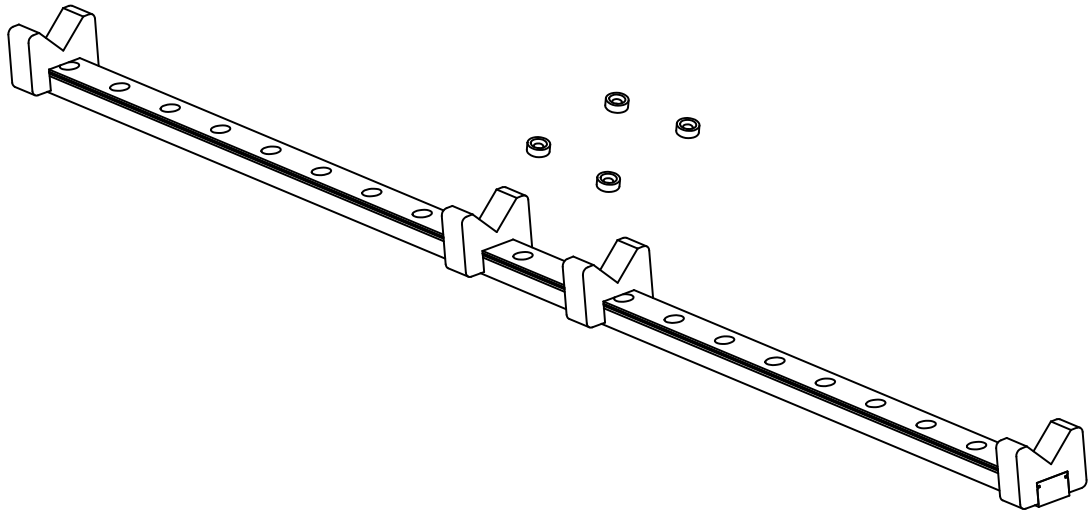
1.3.7 Assembling Instructions

Required Tools and Components

- 1x glue pistol ;
- 1x glue ;
- 1x Torx screwdriver ;
- 4x washer (2 spacer) ;
- 1x threadlocker.

1. Apply **threadlocker** to the four **screw**.
2. Secure the **belt** using the **clamp** and the four **screw-3x** onto the **slider**.
3. Apply **mastic glue** to the **stop**.
4. Ensure the two **spacers** are in place.
5. Apply **threadlocker** to the screws.
6. Fasten the **stop** onto the **clamp**.
7. Allow to cure for 24 hours.

1.3.8 alignator



The purpose of this tool is to align the **male junction** inside the **junction-bloc** during glueing. The **male junction** is screwed in the **rod** the latter is placed on the **v**.

Assemblies In the figure 1.20, page 39 we can see the **alignator** fully assembled with it's components.

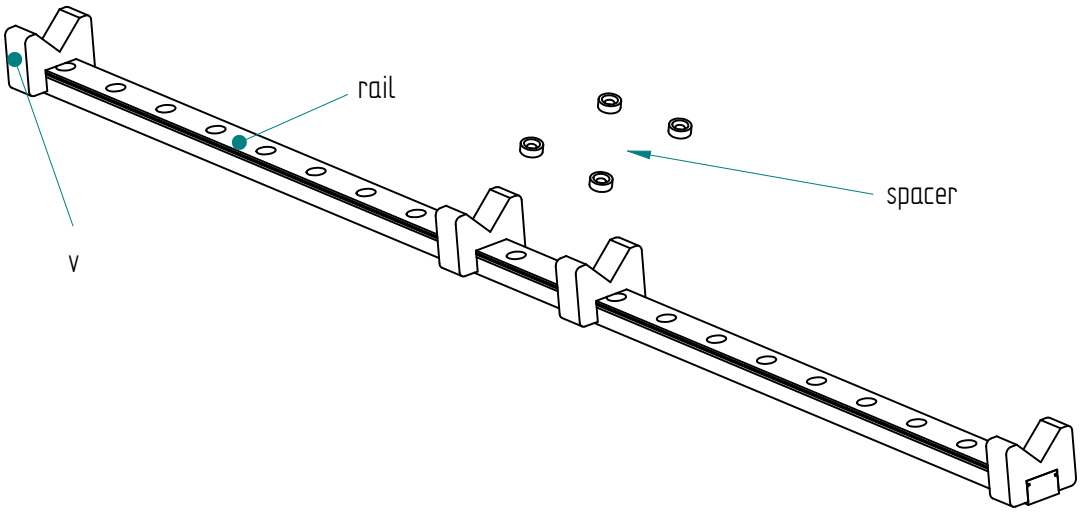


Figure 1.20: **alignator** assembled

Roadmap This paragraph shows how to build the **alignator**.
It's not necessary to follow straight all these points one after another, but I think it's the most logical to do it in these steps I thinks :

1. prepare all stuff in the **Parts list** with the tools showed in the **Tools list** ;
2. assemble the **alignator**.

Parts list In this pargraph we can find the whole list of parts that the perpendiculator needs, like :

- 1 x **rail** ;
- 4 x **spacer** ;
- 1 x PLA (3d printing).

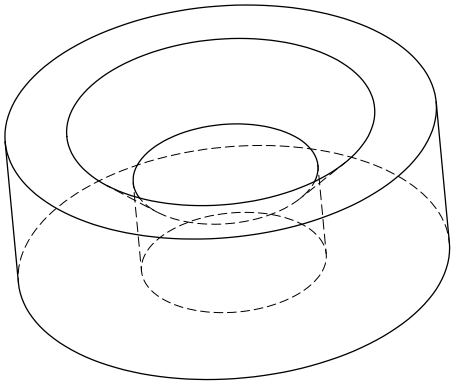
Tools list In this paragraph we can find the list of tools that we need to build the **alignator**, like :

- 3d printer ;
- torks screwdriver.

Shaped-parts In this paragraph we can find the shaped parts that the **alignator** requires, like :

- **spacer** ;
- **v**.

spacer



This paragraph show how to build the **spacer**.

Drawing The figure 1.21, page 41, show the drawing of the **spacer**.

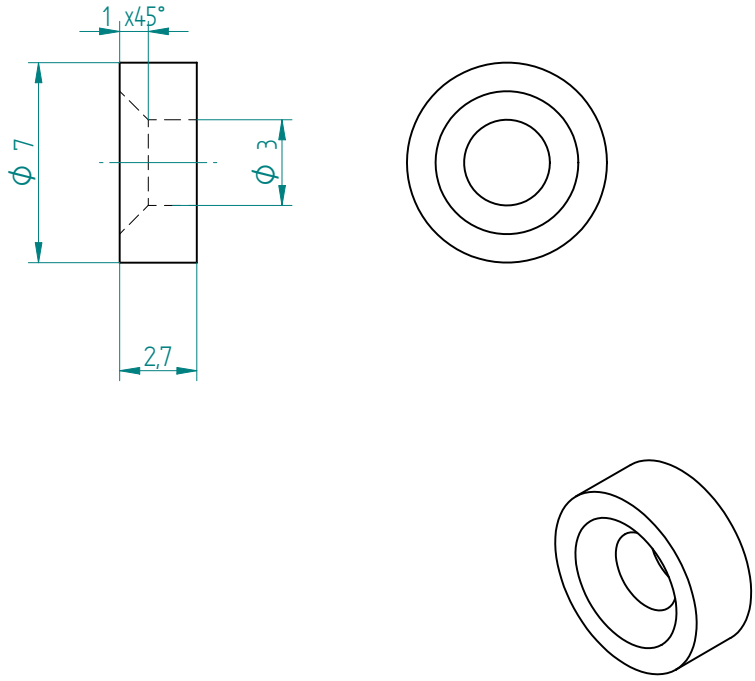


Figure 1.21: **spacer** drawing for **alignator**

Quantity 4 ;

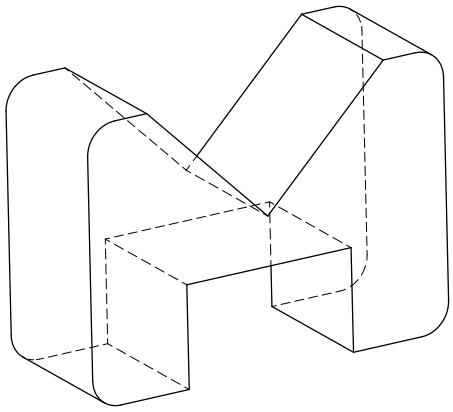
Material PLA 3d printed.

Roadmap

1. copy the file named **UM2_spacer.gcode** from the **3d-print-files** folder to the 3d printer ;

2. print the 4 **spacer** with a 3d printer.

v



This paragraph show how to build the **v**.

Drawing The figure 1.22, page 42, show the drawing of the **spacer**.

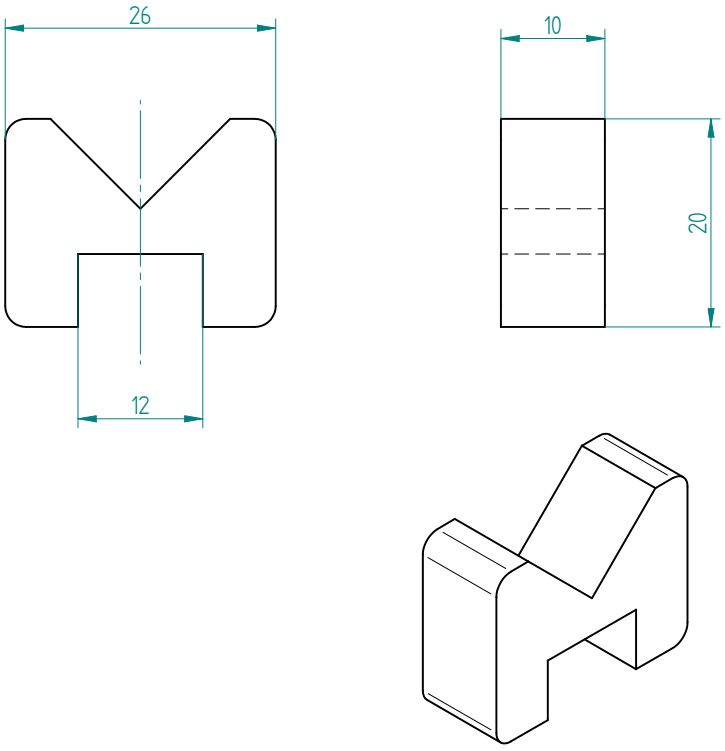


Figure 1.22: **v** drawing for **alignator**

Quantity 4 ;

Material PLA 3d printed.

Roadmap

1. copy the file named **UM2_v.gcode** from the **3d-print-files** folder to the 3d printer ;
2. print the 4 **v** with a 3d printer.

1.4 motor

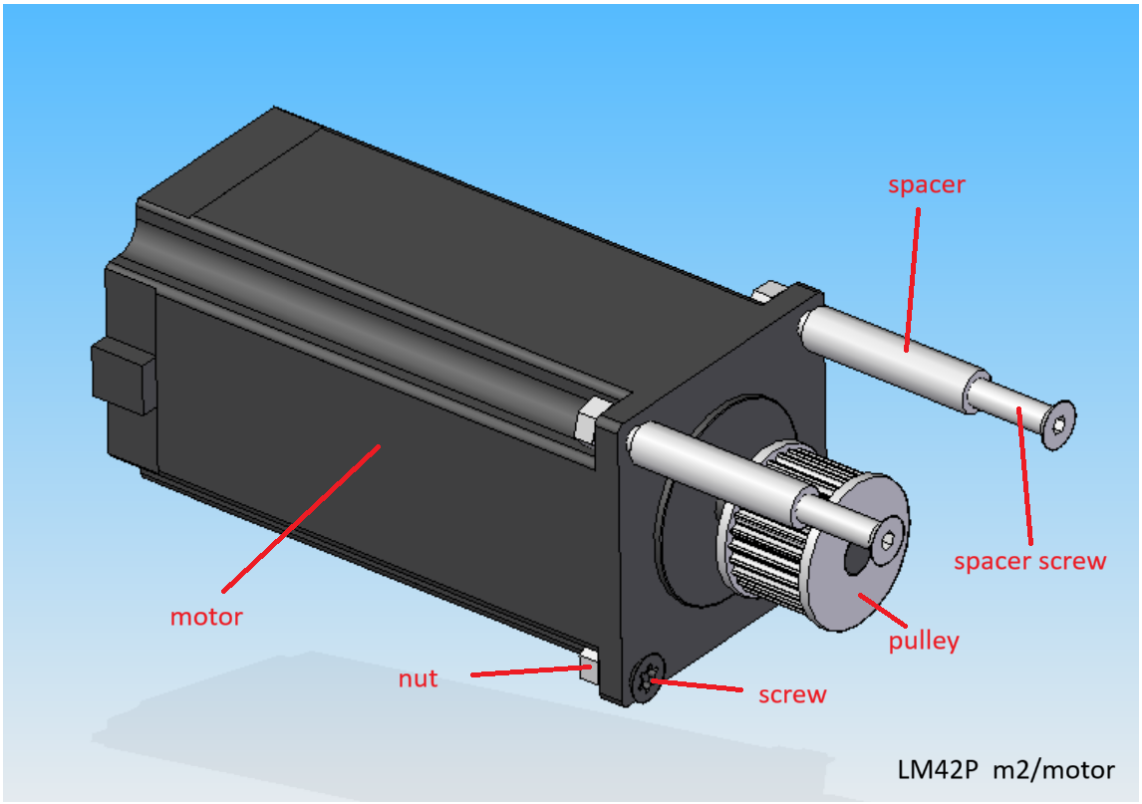


Figure 1.23: m2 motor parts

1.4.1 Parts list

Table 1.7: Parts list of **motor**

Qty	Part	Description	Material
1	**motor**	Nema 23 4.2A 3N.m 112mm	with cable
1	**pulley**	HTD M3 28T 16/8	aluminium
2	**spacer**	M5 x 8 x 35 mm	aluminium
2	**spacer screw**	M5 × 65 mm Torx flat head screw	stainless steel
2	**screw**	M5 × 12 mm Torx flat head screw	stainless steel
4	**nut**	M5	stainless steel

1.4.2 Drawing

See Figure 1.24, page 45.

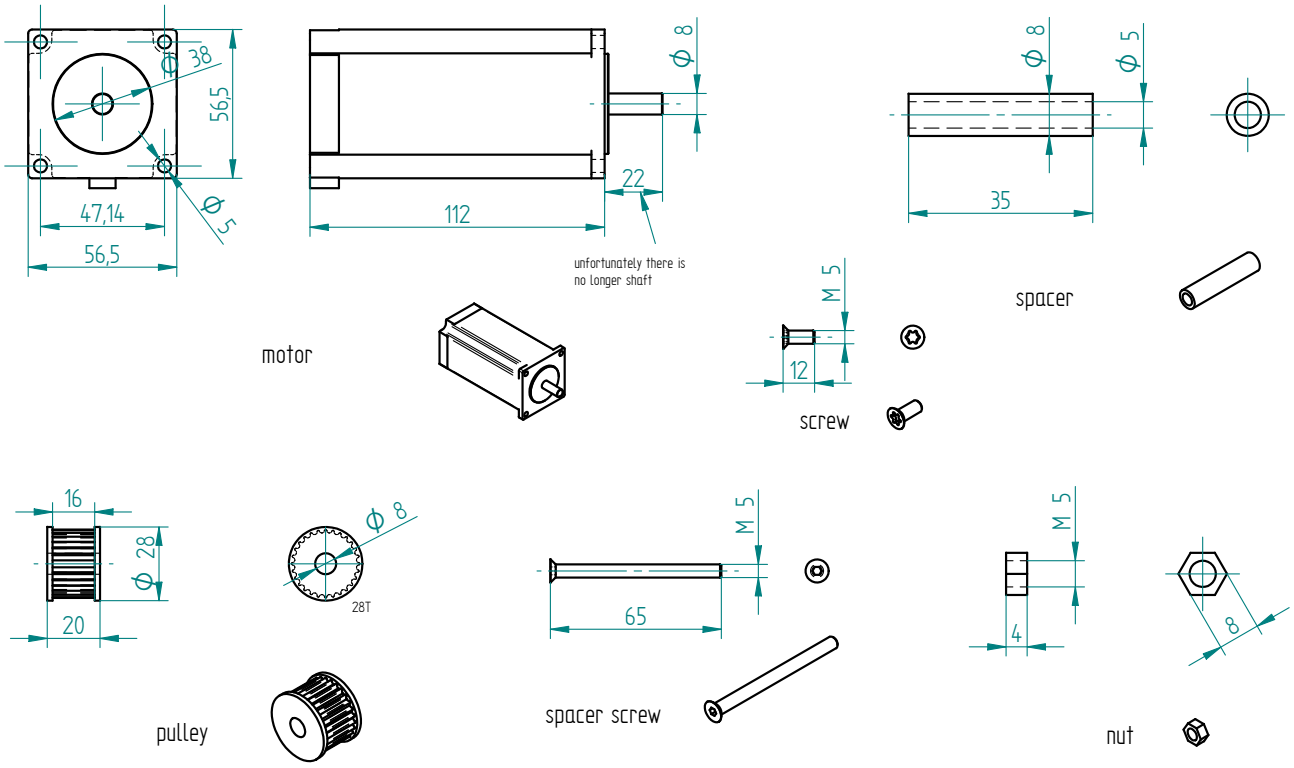


Figure 1.24: Drawing of the motor parts

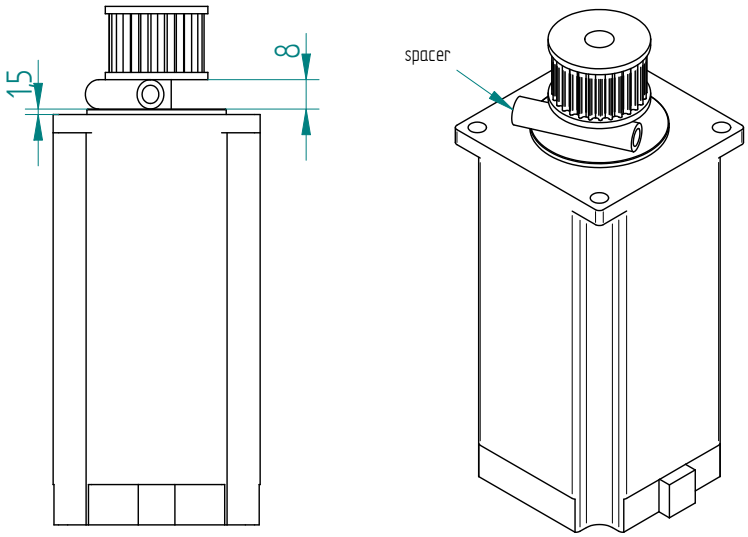


Figure 1.25: Position of the pulley on the motor shaft

1.4.3 Assembling Instructions

Required Tools and Components

- 1x **motor** ;
- 1x **pulley** ;
- 1x **spacer** ;
- 1x adjustable reamer, diameter 8 mm ;
- 1x sandpaper ;
- 1x acetone.
- 1x shaft glue (Loctite 238) ;

1. Test the **pulley** on the **motor** shaft.
   There should be a *slight gap* between them (for the shaft glue).
2. If there is no gap :
   - Use an adjustable reamer (diameter 8 mm) to carefully enlarge the hole in the **pulley** until the **pulley** fits with a slight gap.
3. Clean the shaft and the **pulley** with acetone.
4. Apply shaft glue to the shaft.
5. Press the **pulley** onto the **spacer**, using a **spacer** to ensure correct positioning (See Figure 1.25, page 46.
6. Let it cure for 4 hours.

1.5 idle pulley

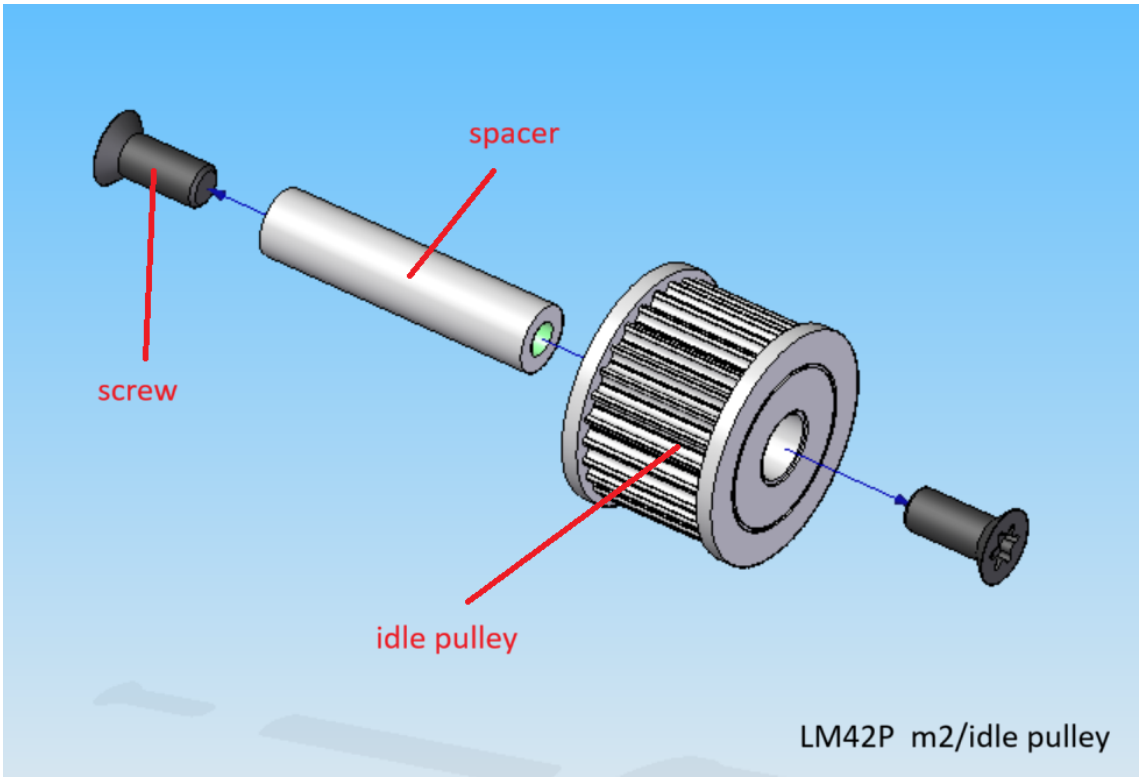


Figure 1.26: m2 idle pulley parts

1.5.1 Parts list

Table 1.8: Parts list of **idle pulley**

Qty	Part	Description	Material
1	**idle pulley**	HTD3 28T / 8	Aluminium
2	**screw**	M5 × 12 mm Torx flat head screw	stainless steel
1	**spacer**	M5 x 8 x 35 mm	Aluminium

1.5.2 Drawing

See Figure 1.27, page 48.

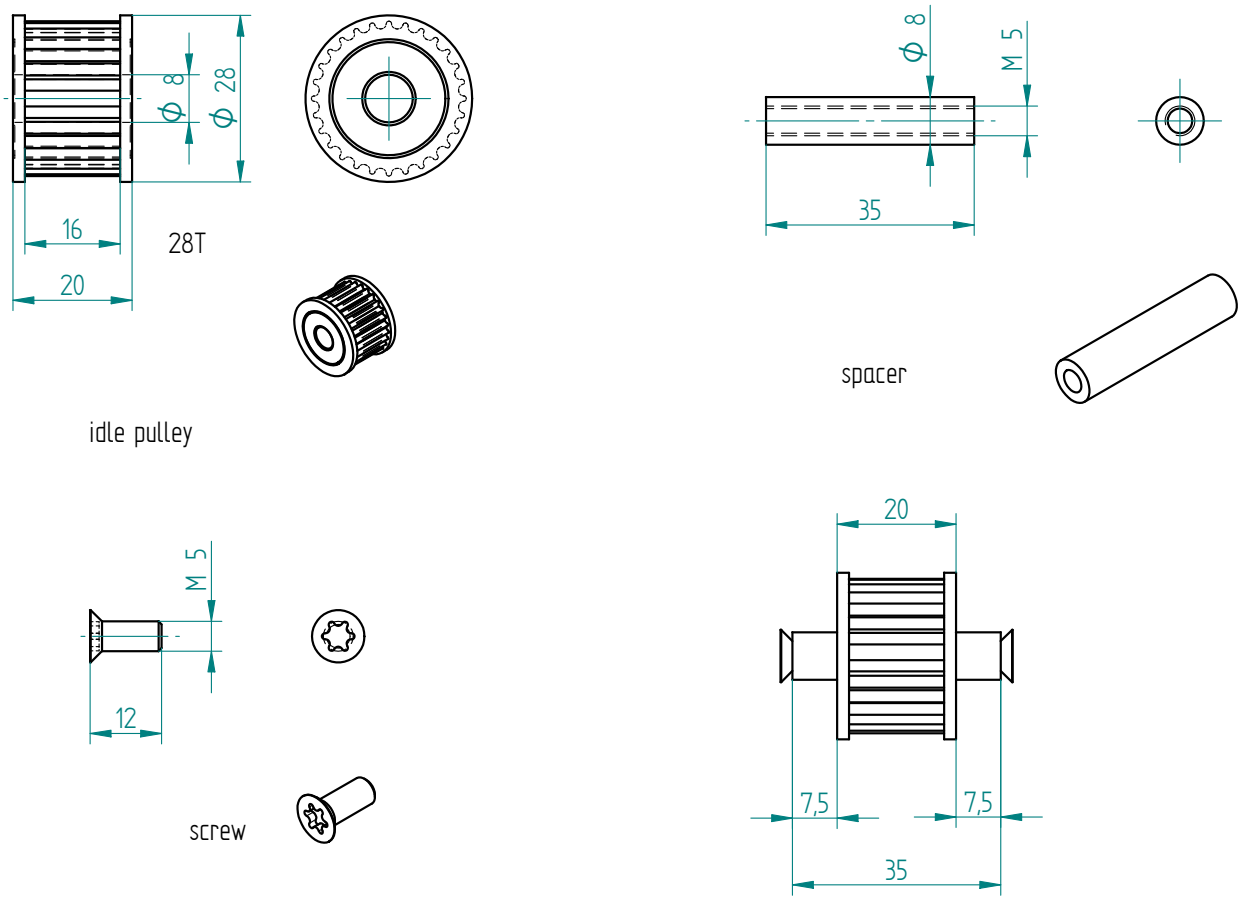


Figure 1.27: Drawing of the idle pulley parts

1.5.3 Assembling Instructions

Required Tools and Components

- 1x **idle pulley** ;
- 1x **spacer** ;
- 1x depth gauge ;
- 1x shaft glue (Loctite 238) ;
- 1x sandpaper ;
- 1x driller ;
- 1x M5 threader shaft ;
- 1x acetone.

1. Test the **idle pulley** on the **spacer**.
   There should be a *slight gap* between them (for the shaft glue).
2. If there is no gap :
   - Insert the threaded shaft into the **spacer** and mount it in a drill.
   - Use **sandpaper** to carefully reduce the outer diameter of the **spacer** until the **idle pulley** fits with a slight gap.
3. Clean the **spacer** and the **idle pulley** with **acetone**.
4. Apply **shaft glue** to the **spacer**.
5. Press the **idle pulley** onto the **spacer**, using a depth gauge to ensure correct positioning (see position Drawing).
6. Let it cure for 4 hours.

1.6 attachment

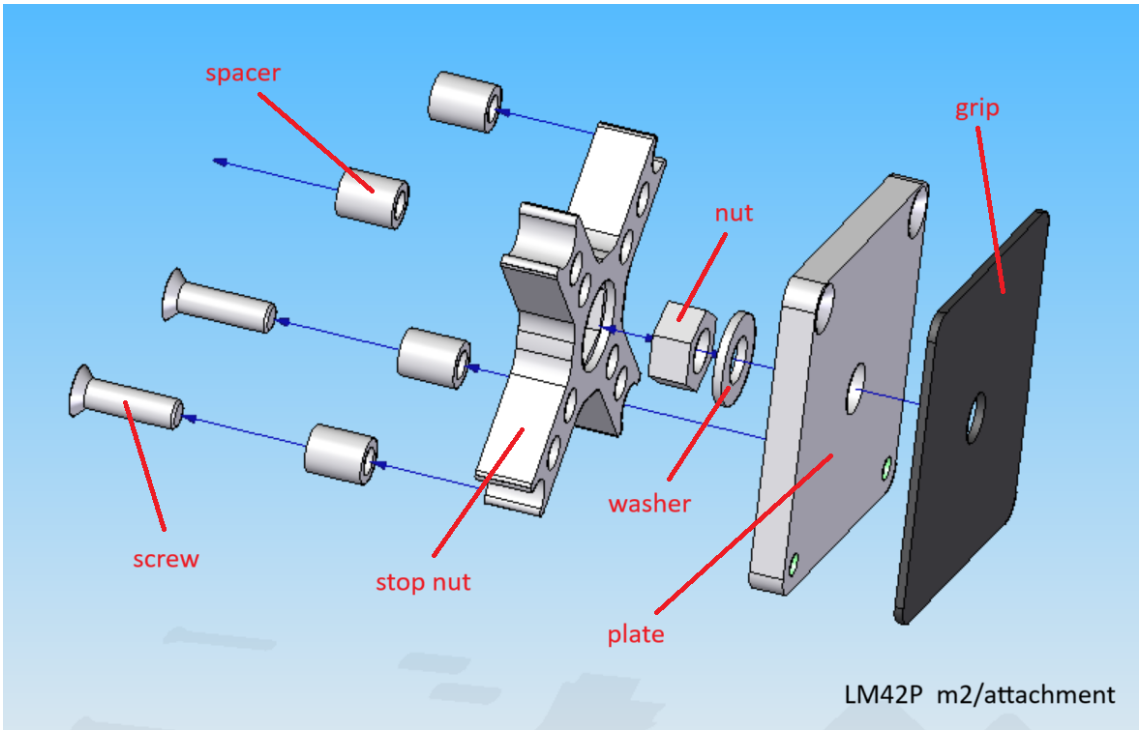


Figure 1.28: m2 attachment parts

1.6.1 Parts list

Table 1.9: Parts list of **attachment**

Qty	Part	Description	Material
1	**plate**	57 x 57 x 6	aluminium
1	**stop nut**	3D Printed	PLA
1	**nut**	M8	brass
1	**washer**	M8 x 8 x 35 mm	stainless steel
4	**spacer**	8 / 5 × 10 mm	aluminium
2	**screw**	M5 x 18 mm Torx flat head screw	stainless steel
1	**grip**	57 x 57	Griptape (skateboard)

1.6.2 Drawing

See Figure 1.29, page 51.

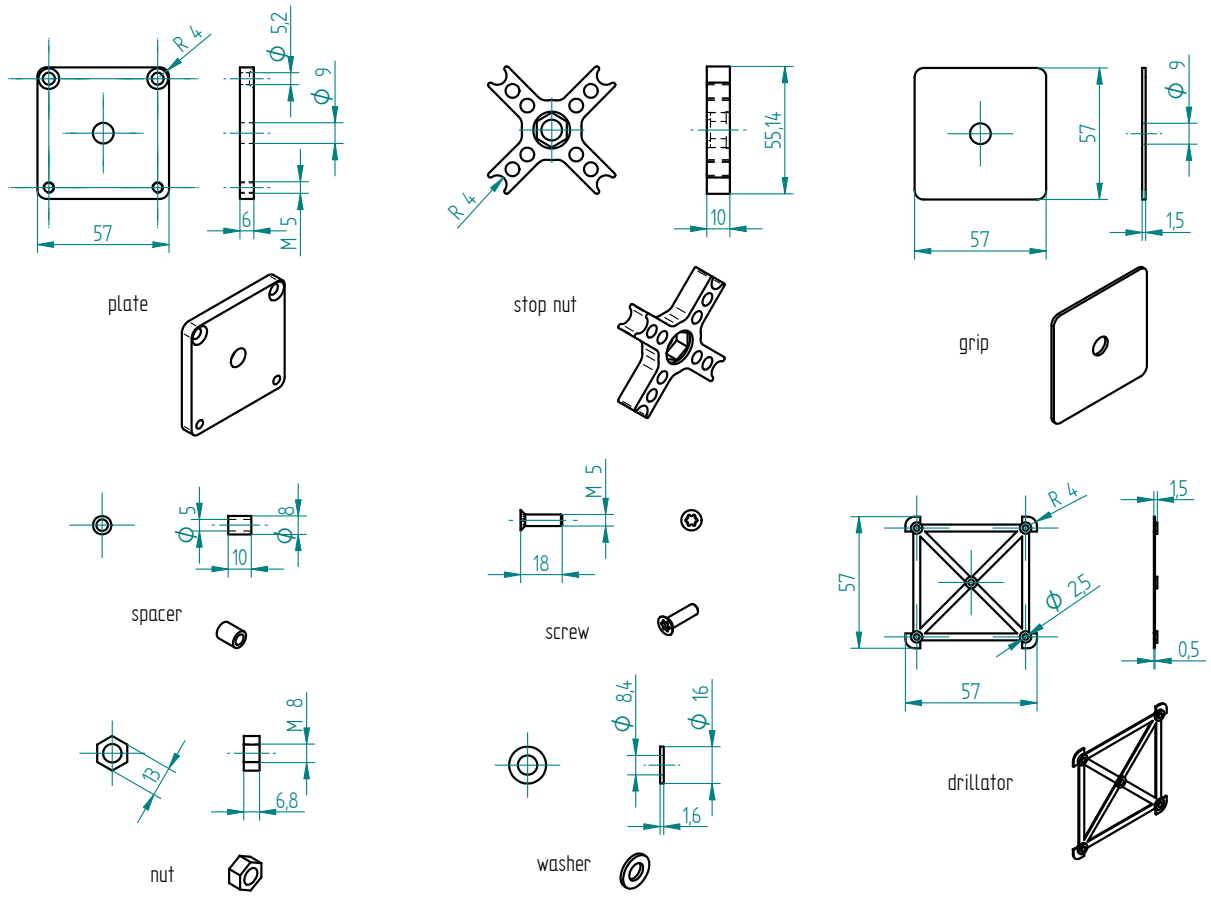


Figure 1.29: Drawing of the attachment parts

1.6.3 Manufacturing Instructions

Required Tools and Components

- 1x aluminium plate 57 x 57 x 6 mm ;
- 1x 3D printer ;
- 1x PLA ;
- 1x STL file (**stop nut**) ;
- 1x STL file (**drillator**) ;
- 2x clamp ;
- 1x scriber ;
- 1x file ;

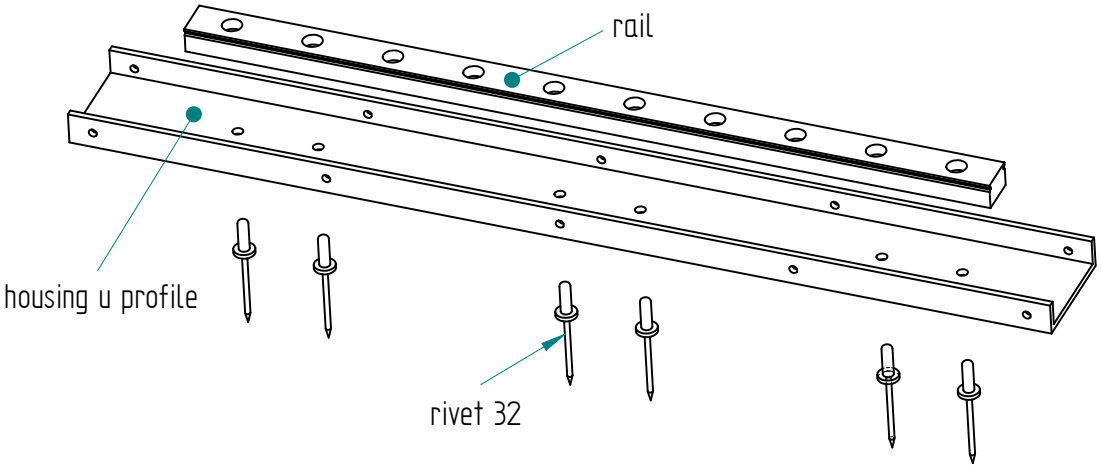
- 1x 2.5 mm drill bit ;
- 1x 5.2 mm drill bit ;
- 1x 4.2 mm drill bit ;
- 1x 9 mm drill bit ;
- 1x M5 tap ;
- 1x Griptape 57 x 57 mm (use for skate board) ;
- 1x drill press ;
- 1x driller.

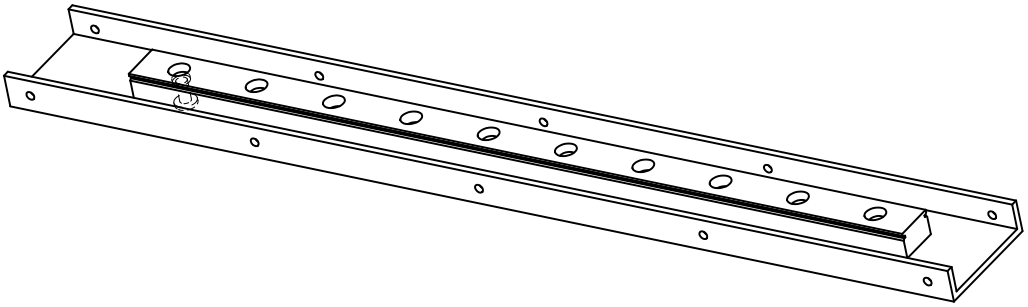
1. 3D print the **drillator** ;
2. 3D print the **stop nut** ;
3. clamp the **drillator** on the aluminium plate ;
4. scribe the 4x radii and the holes ;
5. drill and tap all holes ;
6. file the 4 radii ;
7. file the sharp edges ;
8. cut and drill the **grip**.

1.7 Assembling Instructions

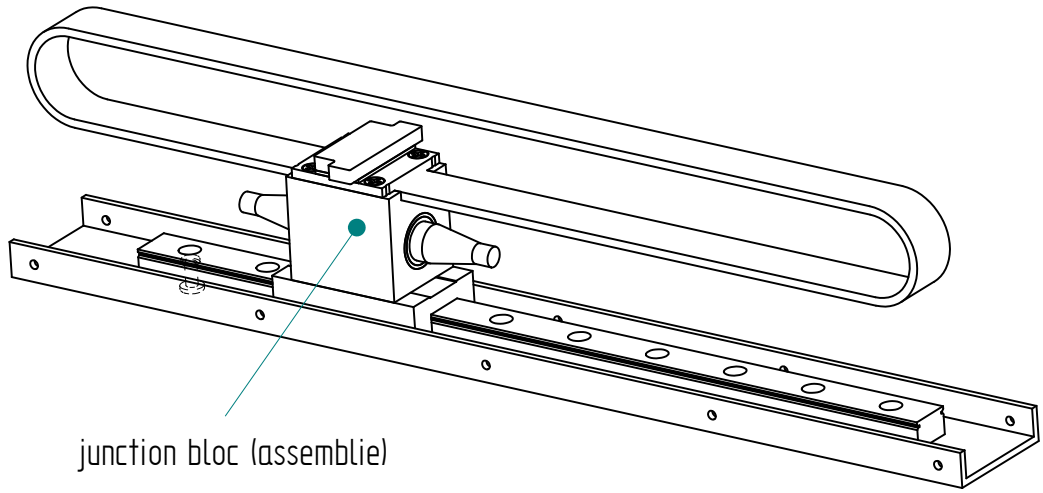
Remark All screws must be glued using threadlock glue.

1. Fabricate the shaped tools: the **tensionator** and the **drillator** (refer to section **tensionator** and **drillator**).
2. Rivet the **rail** onto the **housing U-profile**.

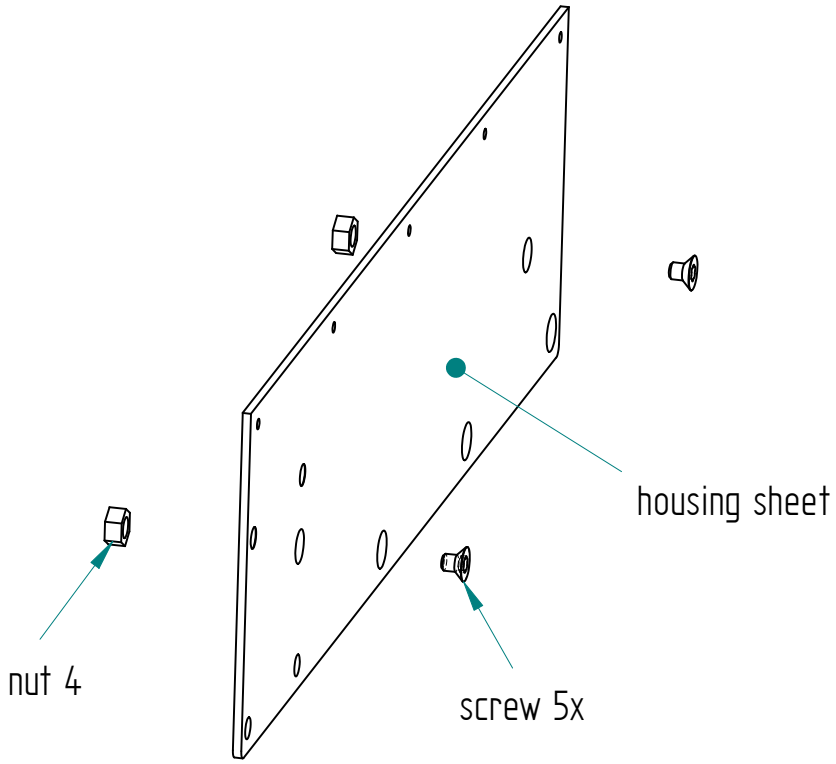


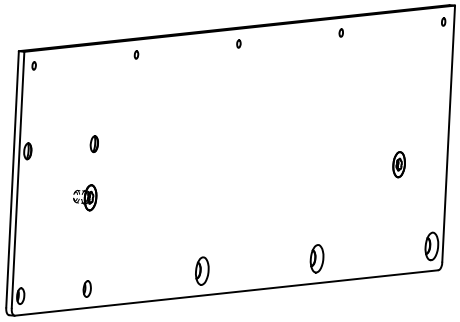


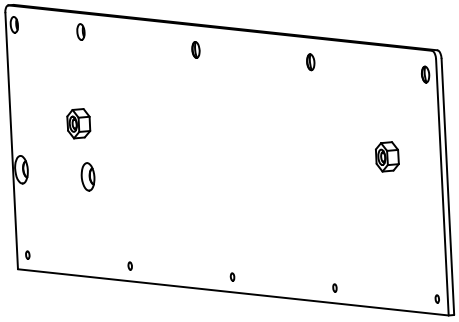
3. Slide the **junction block** (assembly) onto the **rail**.

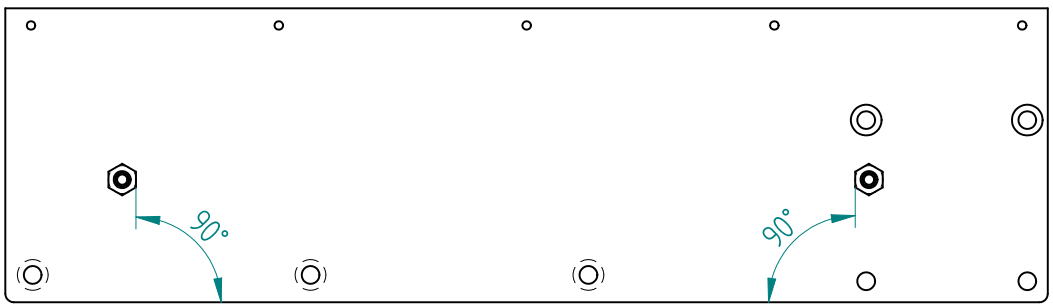


4. Mount the **stop screw nut**, ensuring proper alignment. Glue with **threadlock glue** and **mastic glue**. After curing, file the **5x screw** so it does not protrude.

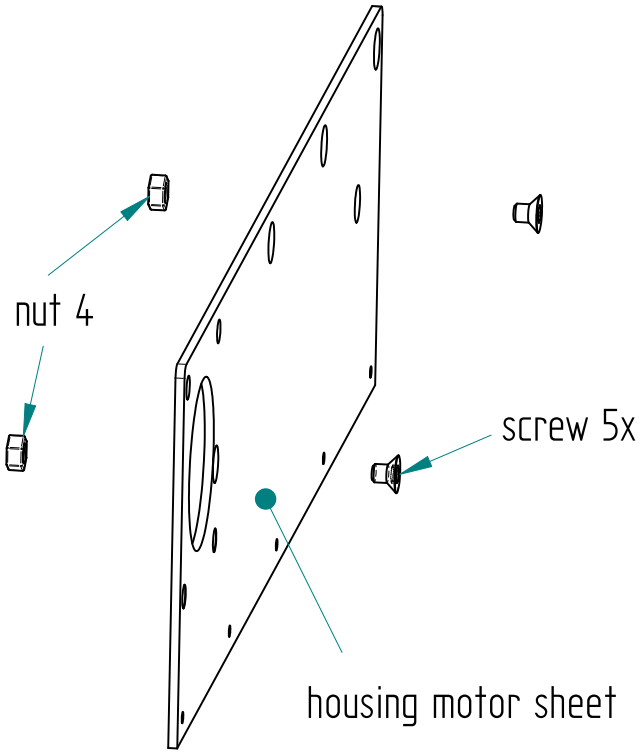


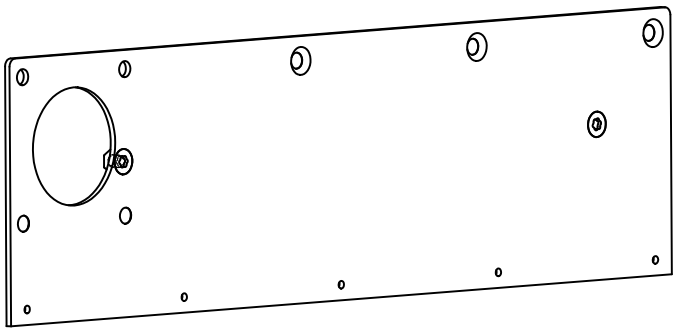


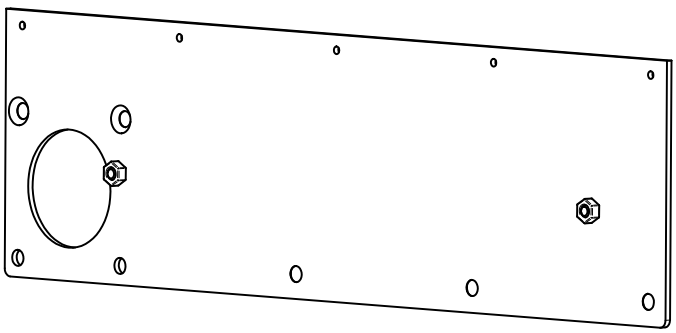


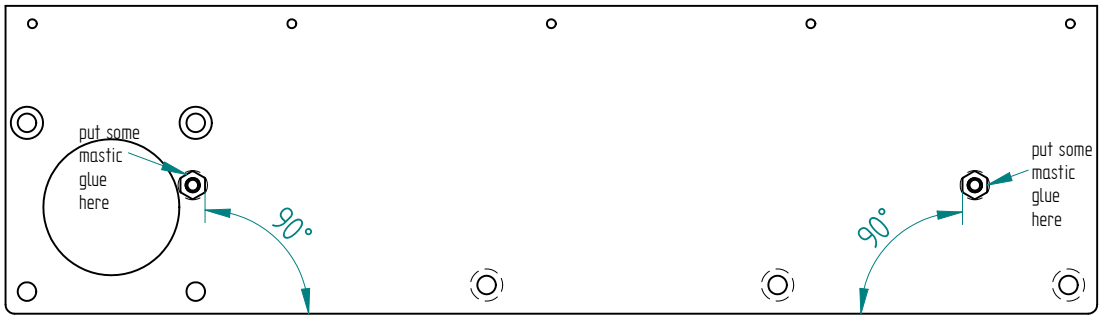


5. Repeat the previous step to mount the second **stop screw nut**.


nut 4
screw 5x
housing motor sheet

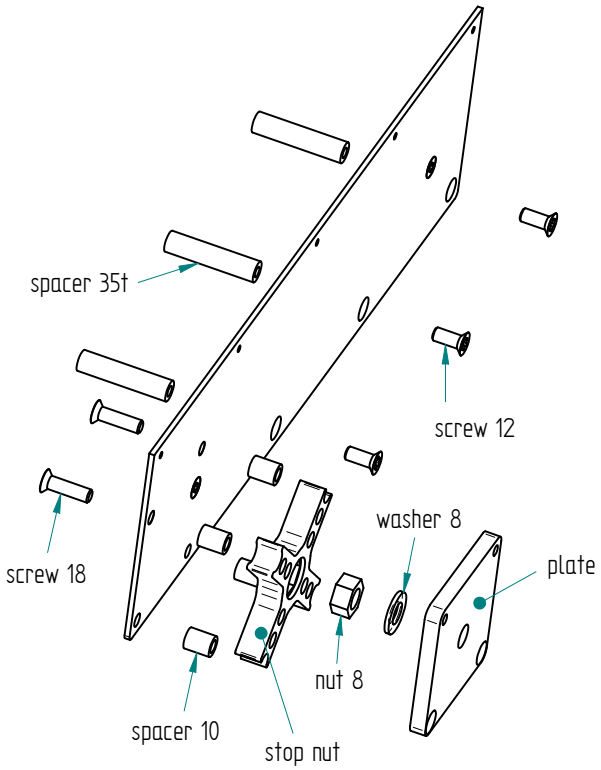


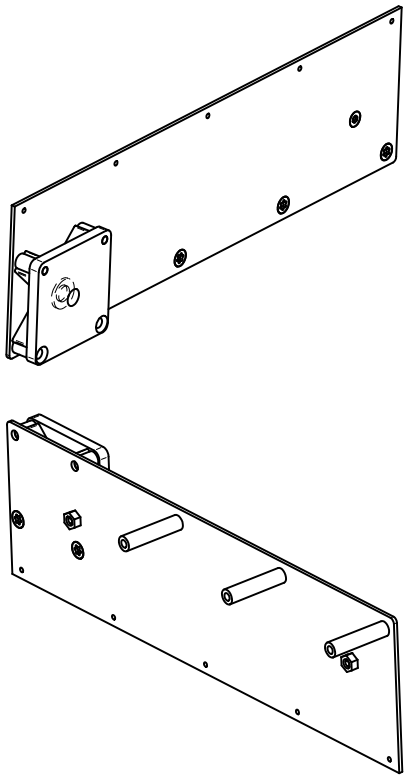




6. Assemble the following components:

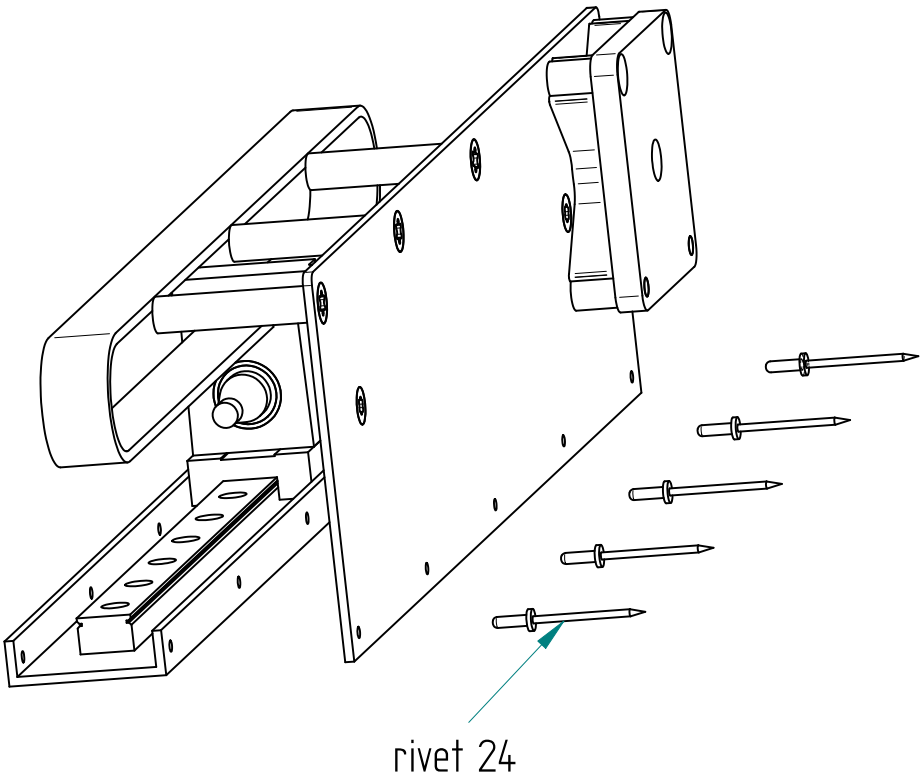
- 3 × **spacer 35**
- 3 × **screw 12**
- 4 × **spacer 10**
- 2 × **screw 18**
- 1 × **stop nut**
- 1 × **nut 8**
- 1 × **washer 8**
- 1 × **plate**

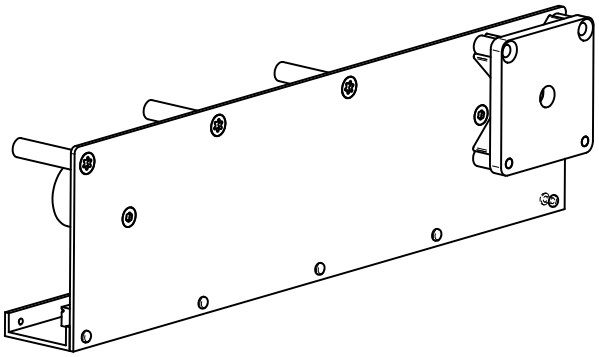


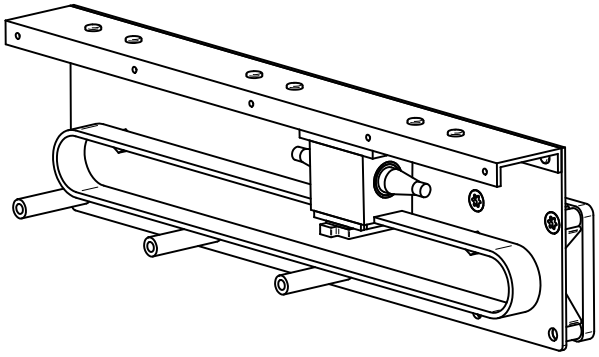


7. Rivet the following:

    - 5 × **rivet 24**





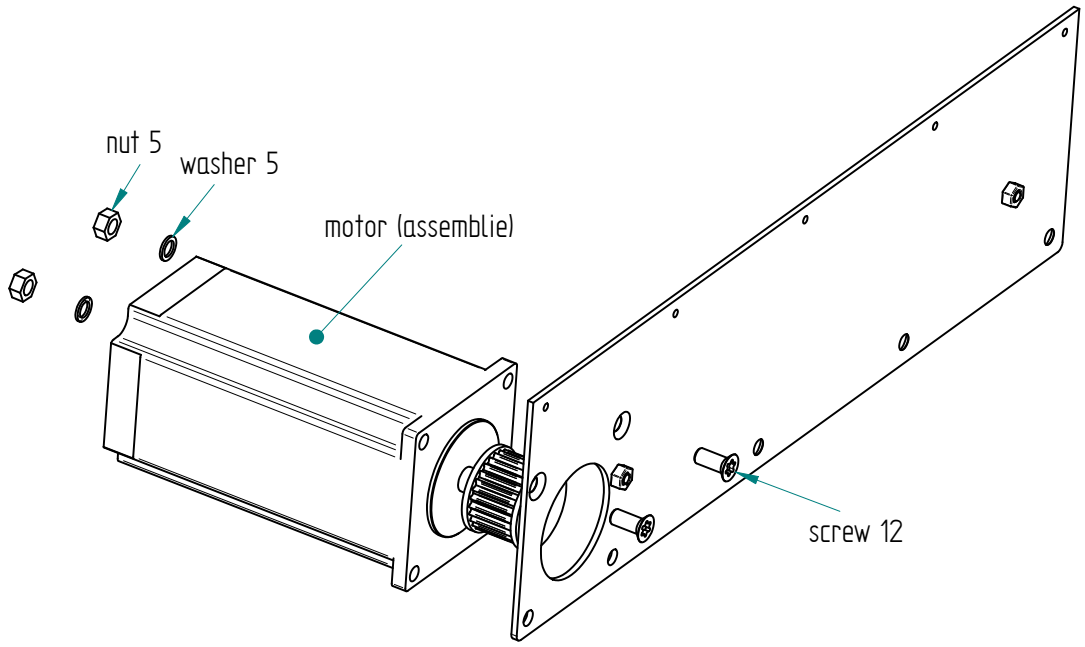


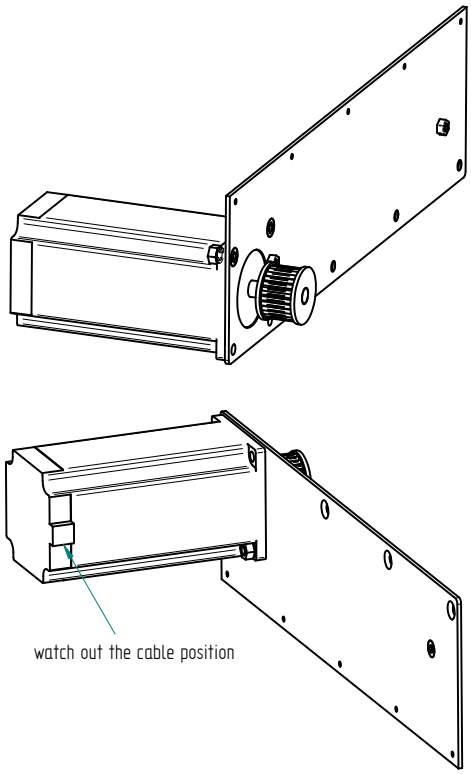
8. Secure the **motor** (assembly) with:

   - 2 × **screw 12**

- 2 × **washer 5**
- 2 × **nut 5**

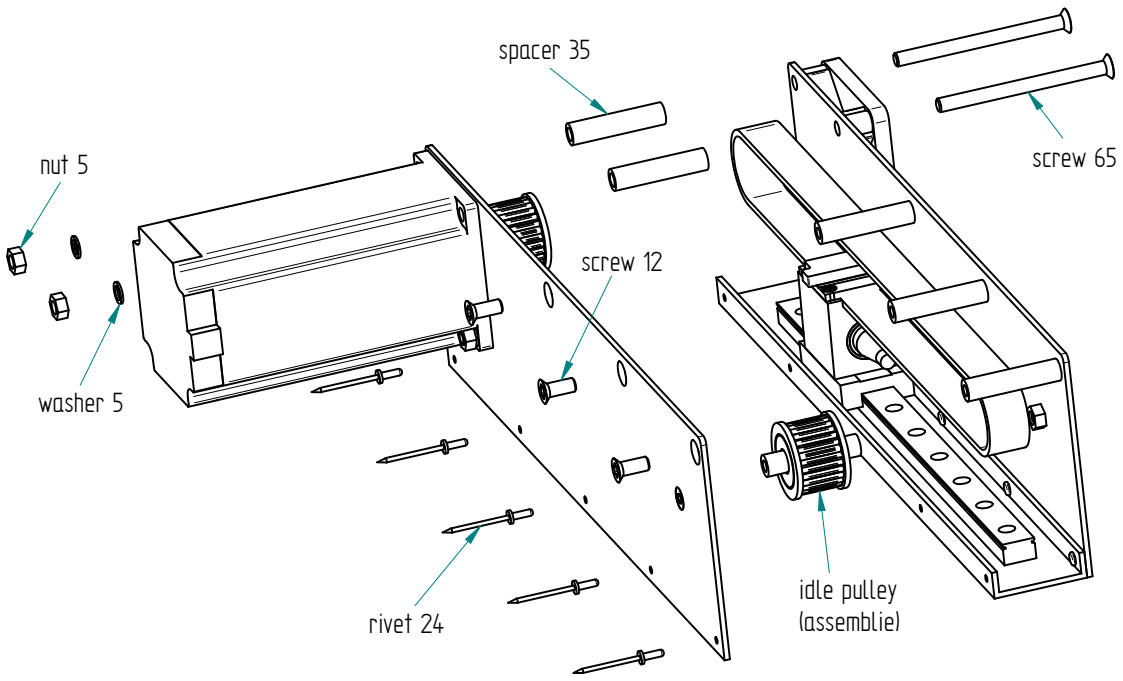
Ensure the cable is properly oriented.

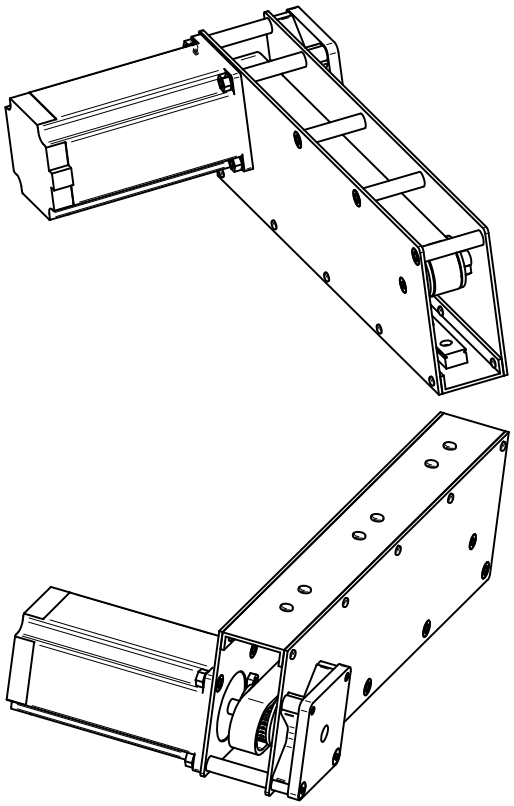




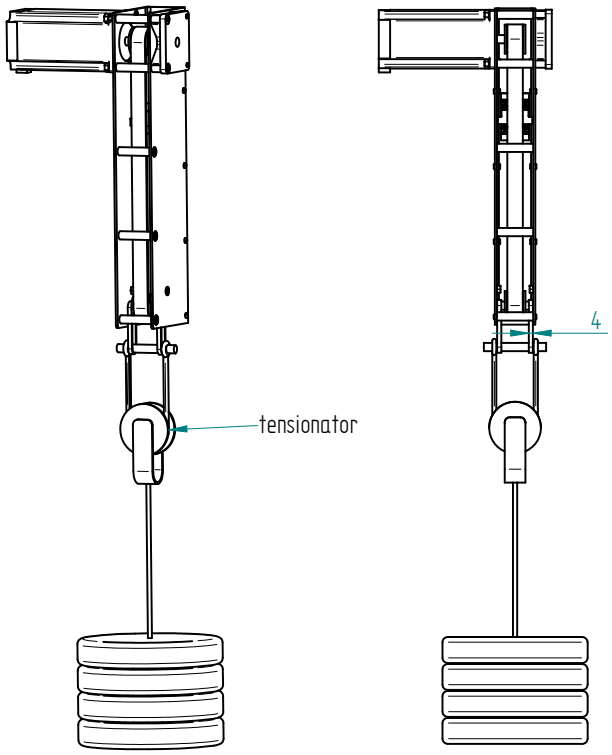
9. Close the housing using the **idle pulley** (assembly), with:

- 2 × **screw 65**
- 2 × **spacer 35**
- 2 × **washer 5**
- 2 × **nut 5**
- 3 × **screw 12**
- 5 × **rivet 24**
- 1 × **idle pulley** (assembly)



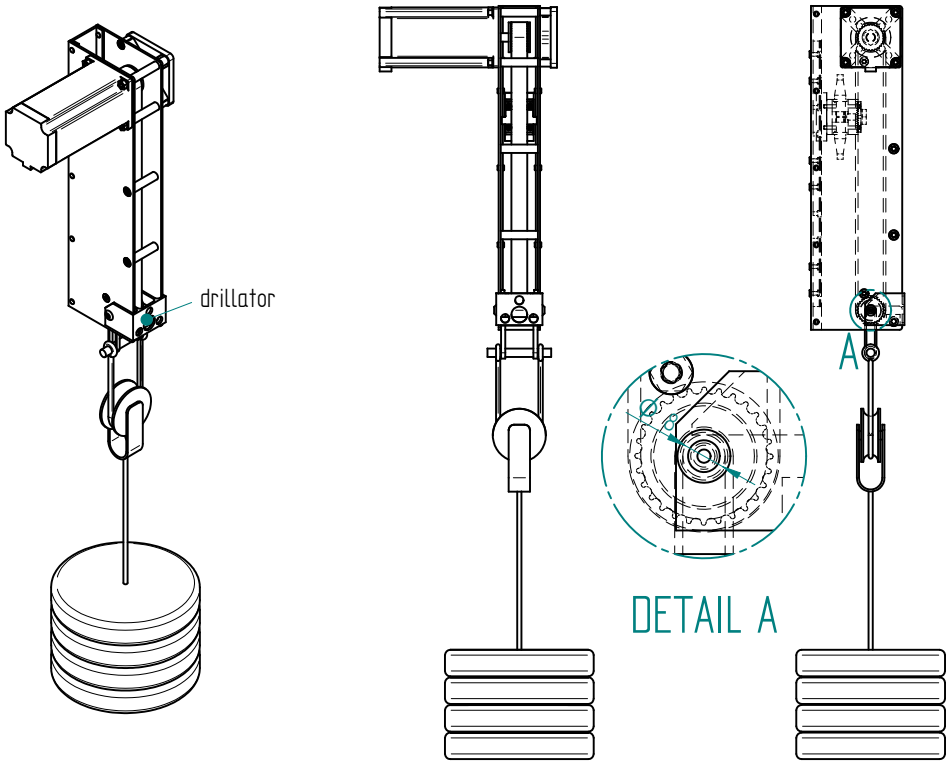


10. Attach the shaped tool **tensionator** to the **idle pulley** using 2 × **colson 4**.



11. Place a weight of approximately 17 kg (e.g., 11 × 1.5 L bottles).

12. Mount the shaped tool **drillator**.



13. Mark drill points using a **2.5 mm drill** on both sheets.
14. Drill with a **5 mm drill**, then chamfer the holes. *Test the depth using a screw.*
15. Tighten the **idle pulley** using 2 × **screw 12**.
16. Well Done you've finished the **m2** !

1.7.1 drillator

This section shows how to make the shaped tool named **drillator** The purpose of this tool is to point the holes of the **idle pulley** shaft during tensioning the **belt**.

Drawing

The figure 1.30, page 64, shows the drawing of the **drillator**.

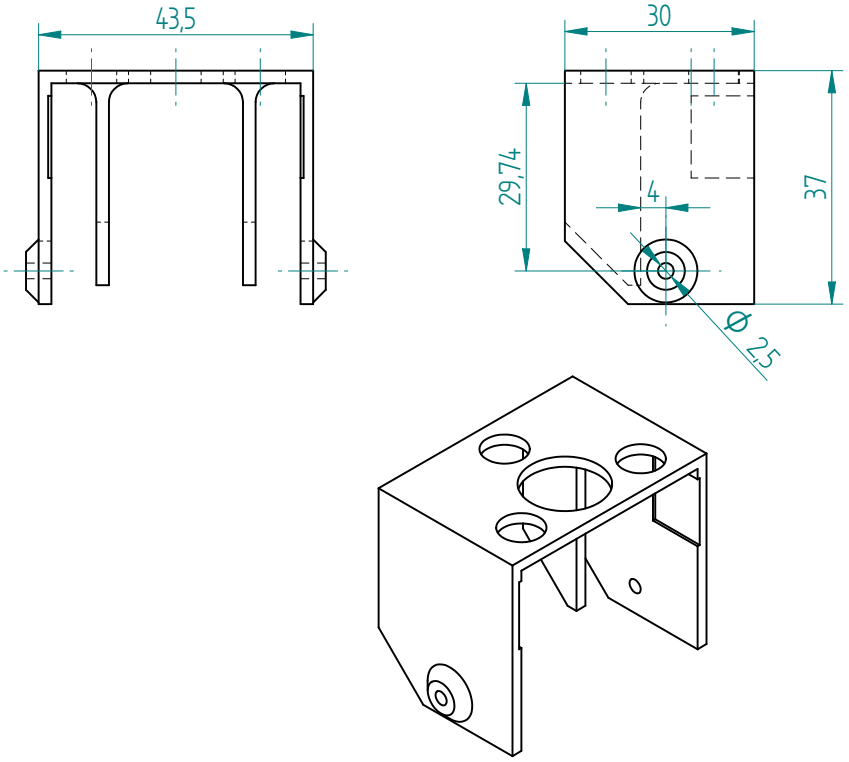


Figure 1.30: drawing of the **drillator**

Details

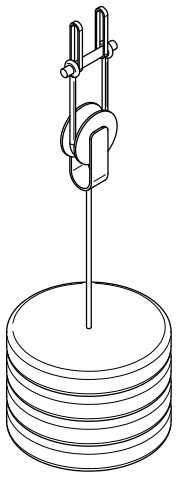
Quantity 1 ;

Material PLA ;

Manufacturing Instructions

1. 3d print the **drillator** the files are in the folder named **3d-print-files**.

1.7.2 tensionator



This section explains how to build the shaped tool called the **tensionator** for the assembly of the **m2** machine.

Drawing The figure 1.31, page 65, shows the drawing of the **tensionator** with all its elements.

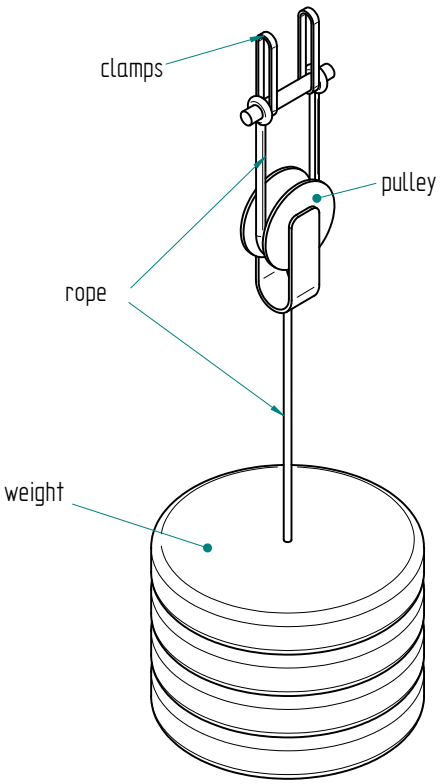


Figure 1.31: **tensionator** and its elements

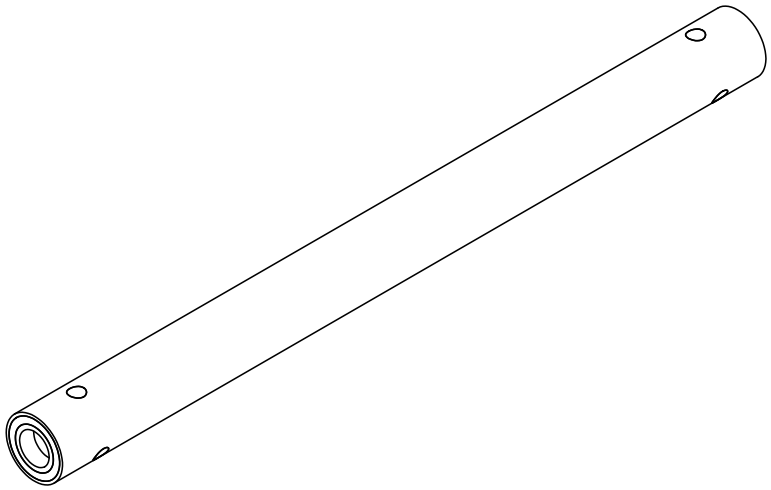
Table 1.10: Parts list of **tensionator**

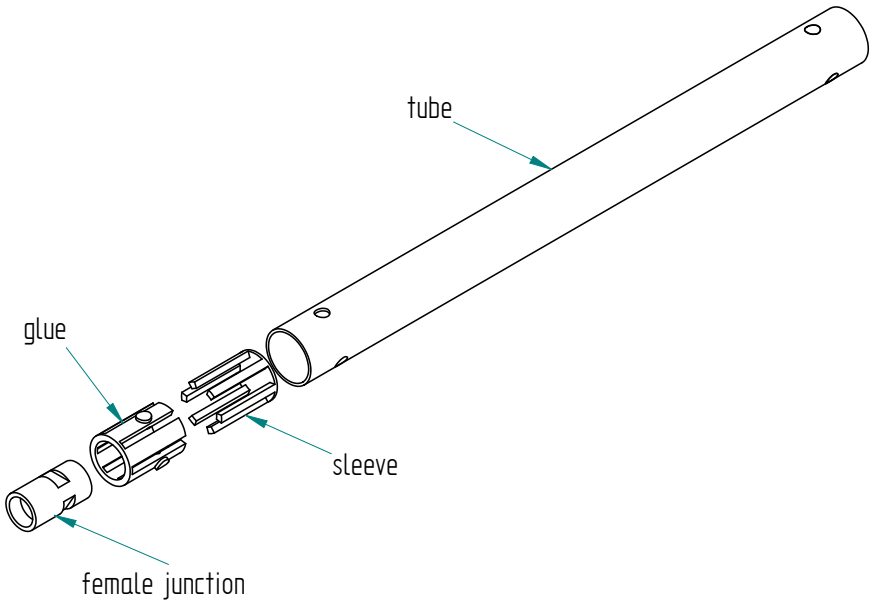
Qty	Part	Description	Material
1	pulley	D50 mm	-
1	colson	4 mm	-
2	rope	-	-
1	weight	17 kg	-

Chapter 2

m2 accessories

2.1 rod





2.1.1 Parts list

Table 2.1: Parts list of the **rod**

Qty	Part	Description	Material
1	tube	20/18,length: 250 mm	carbon
1	female junction	google : `pool cue junction`	brass
1	sleeve	3D printed	PLA
1	glue	resin, hardner, graphite powder	

2.1.2 Drawing

See Figure 2.1, page 69.

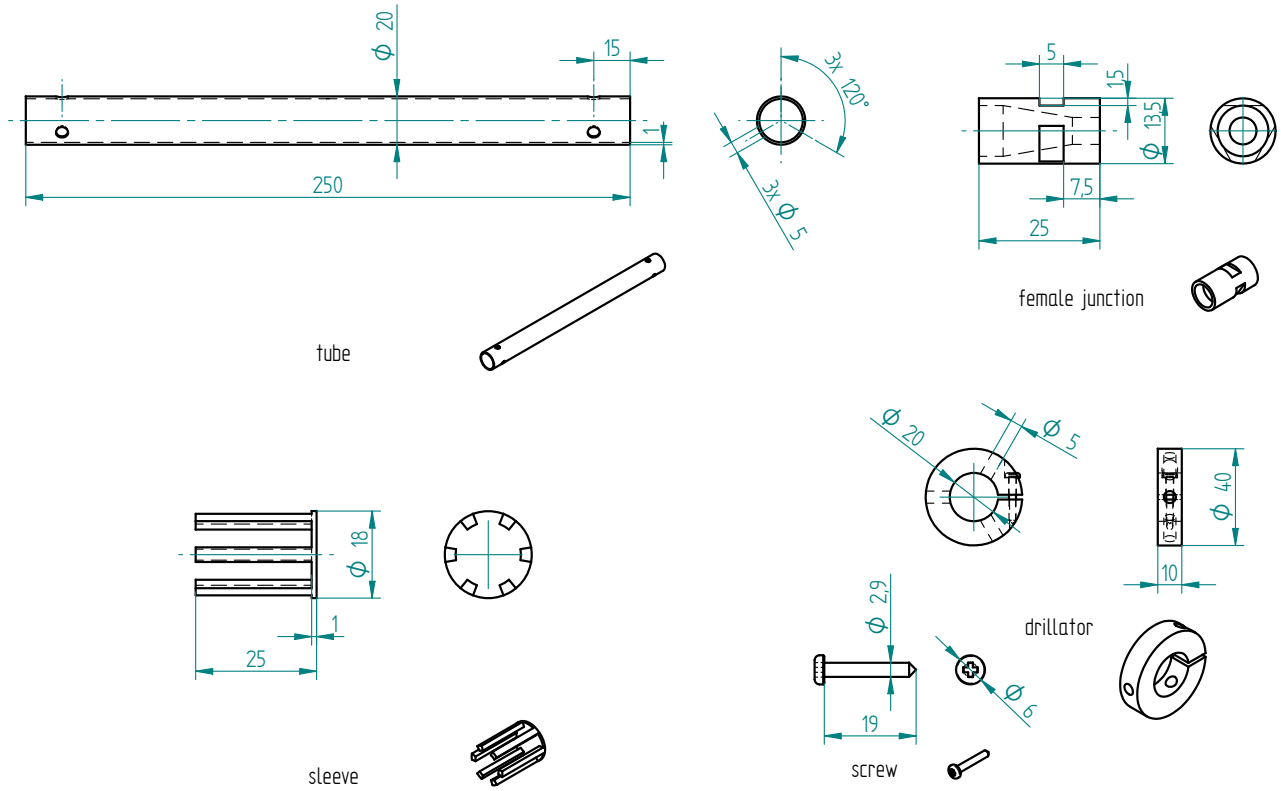


Figure 2.1: Drawing of the **rod** parts

2.1.3 Manufacturing Instructions

Required Tools and Components

- 1x carbon tube length: 500 mm ;
- 1x paper ;
- 1x tape ;
- 1x handsaw ;
- 1x perpendiculator ;
- 1x drillator ;
- 1x 5mm drill bit ;
- 1x driller ;

- 1x sandpaper ;
- 1x 3D printer ;
- 1x PLA filament ;
- 2x female junction ;
- 1x file ;

tube

1. Scribe a mark at the exact middle of the carbon tube.
2. Wrap a piece of paper around the tube and secure it with tape (to guide the cut).
3. Use a handsaw to cut the tube into two equal parts.
4. Make both ends of each tube perpendicular using the **perpendiculator** tool.
5. Remove the sharp edges with sandpaper.
6. Drill the 6 holes using the driller and the **drillator** tool (refer to the Drawing section).
7. Remove the sharp edges again with sandpaper.

sleeve

1. 3D print the part using the files located in the `3d-print-files` directory.
2. Chamfer the edges using a file.
3. Insert the female junction into the sleeve and gently push it into the tube. Adjust if there is too much friction or too large a gap.

female junction

1. File the three 5/1.5mm flats—see dimensions in the **Drawing** section.

2.1.4 Assembly Instructions

Required Tools and Components

- 1x hot glue ;
- 1x **male junction** ;
- 1x tape ;
- 1x scale ;
- 1x glue :
  - resine:

Brand ? ;
Type ?.

– hardner:

Brand ? ;
Type ?.

- 1x graphite powder :

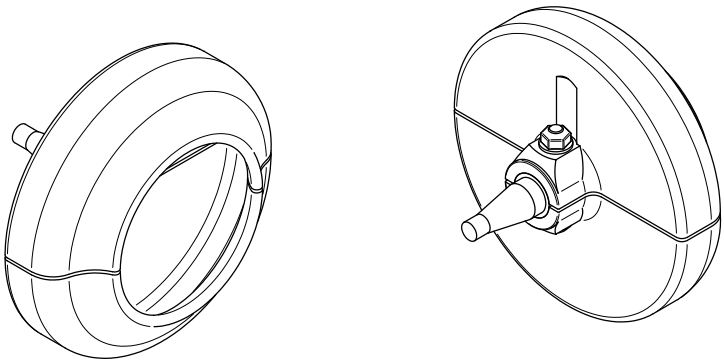
  Brand Suter Kunstoff AG ;
  Type West Graphit-Pulver 423.

- 1x clamp ;
- 1x piano wire ;
- 1x oven ;
- 1x perpendicalor.

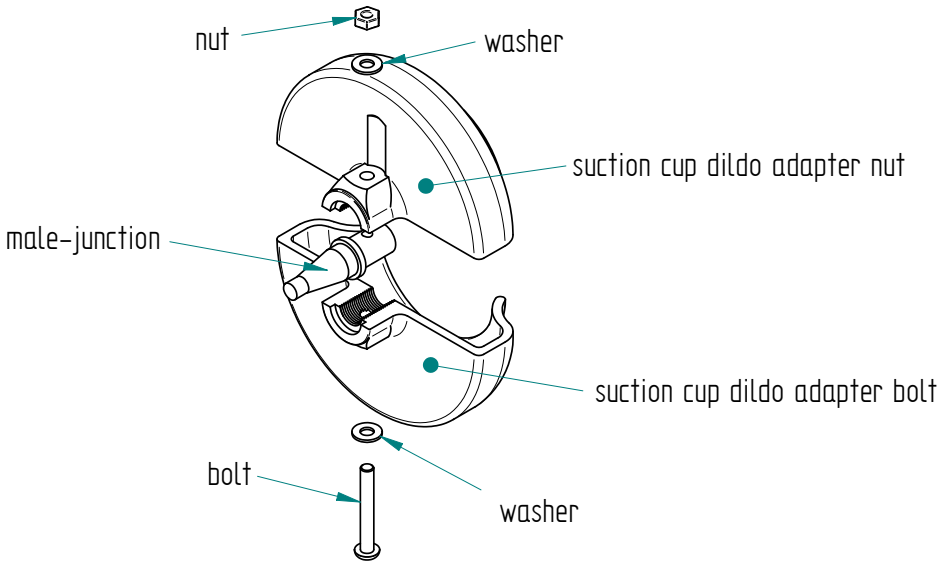
1. Screw the **male junction** into the **female junction**.
2. Seal the hole with hot glue.
3. Trim any excess hot glue using a scalpel.
4. Unscrew the **male junction**.
5. Thoroughly clean the outside and top of the **female junction** with acetone.
6. Seal the hole with tape.
7. Using a scalpel, carefully cut the tape around the **female junction**.
8. Insert the **female junction** into the **sleeve**, ensuring the flat side aligns with the canals inside the **sleeve**.
9. Push the assembly into the **tube** until the **female junction** is aligned with the end of the **tube**. Use a ruler for accuracy. Press on the tape — it's normal for the **female junction** to move slightly inward due to the tape's thickness.
10. Wrap tape around the end of the **tube**, with the tape's edge extending about 1 mm above the end of the **tube**.
11. To glue two **female junctions**, prepare the following mixture:
    - 1.5 g of **hardener** ;
    - 3.75 g of **resin** ;
    - 1.125 g of **graphite powder**.
12. Prepare **glue**, as described in the shaped-parts section, and mix it with **graphite powder**.

13. Use a clamp to hold the **tube** vertically.
14. Pour the glue mixture above the tape, letting it slightly overflow past the end of the tube.
15. Use piano wire to enter each canal of the **sleeve**, removing any bubbles and ensuring **glue** flows properly into the canals.
16. Let the **glue** set for 2 hours.
17. After 2 hours, check the level of the composite. Add more if necessary.
18. Allow to cure for 24 hours, or place in an oven to accelerate curing.
19. Use the **perpendiculator** to grind the end of the **tube** until the tape sealing the **female junction** is removed (you should see a shiny ring appear).
20. Repeat the same steps for the other end of the **tube**.

2.2 suction cup dildo adapter



This section explain how to build the **suction cup dildo adapter** for the **m2** machine.



2.2.1 Parts list

Table 2.2: Parts list of **suction-cup-adapter**

Qty	Part	Description	Material
1	**suction cup dildo adapter nut**	3D printed	PLA
1	**suction cup dildo adapter bolt**	3D printed	PLA
1	**male junction**	google : pool cue junction	brass

continued on next page ...

... continued

Qty	Part	Description	Material
1	**bolt**	M4 x 30 mm	stainless steel
1	**nut**	M4	brass
2	**washer**	M4	stainless steel

2.2.2 Drawing

See Figure 1.27, page 48.

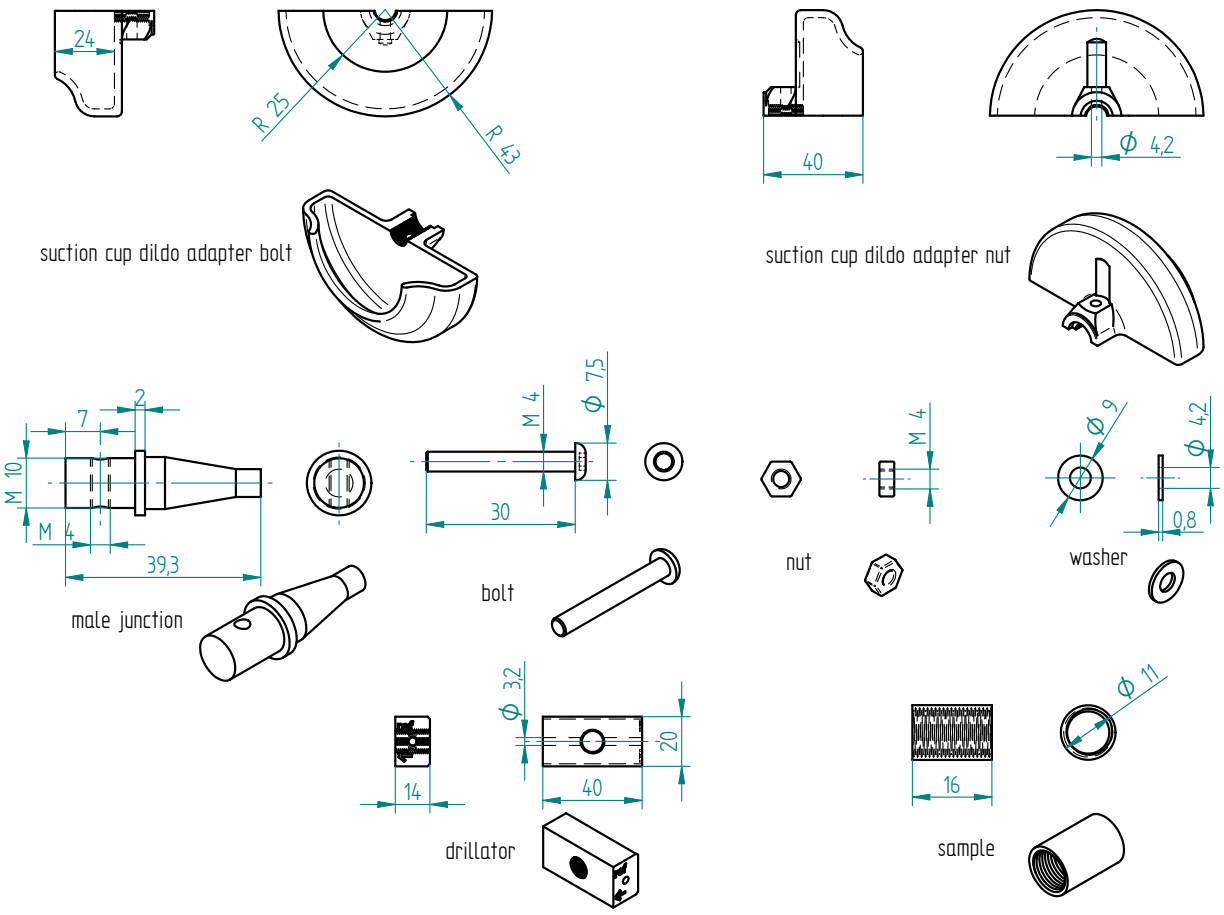


Figure 2.2: Drawing of the suction cup dildo adapter parts

2.2.3 Manufacturing Instructions

Required Tools and Components

- 1x 3D printer ;
- 1x CAD software (to ajuste M10 tap in case) ;
- 1x PLA ;
- 1x STL file **suction cup dildo adapter nut** ;

- 1x STL file **suction cup dildo adapter bolt** ;
- 1x STL file **drillator** ;
- 1x STL file **sample** ;
- 1x **male junction** ;
- 1x **bolt** ;
- 2x **washer** ;
- 1x **nut** ;
- 1x file ;
- 1x 3.2 mm drill bit ;
- 1x chamfer mill ;
- 1x M4 tap ;
- 1x tap wrench ;
- 1x boltdriver ;
- 1x drill press ;
- 1x driller ;
- 1x water pump pliers ;
- 1x allen key ;
- 1x threaderlock glue ;
- 1x bench vise.

1. Skip the next three steps if all 3D printers used print with the same accuracy as an Ultimaker.
2. 3D print the **sample**.
3. Test if the M10 tap fits into the **sample**.
4. Adjust the M10 tap size on the **suction cup dildo adapter nut**, **suction cup dildo adapter bolt**, and **drillator** 3D models as needed.
5. 3D print the **suction cup dildo adapter nut**, **suction cup dildo adapter bolt**, and **drillator**.
6. Screw the **male junction** into the **drillator** (the large diameter with a width of 2 mm should be flush against the reference plane). Use water pump pliers.
7. On a drill press, drill a 3.2 mm hole.

8. File or chamfer the hole.
9. Tap an M4 thread.
10. Assemble the **male junction** and **suction cup dildo adapter bolt** with the **bolt**. Don't forget to apply thread locker.

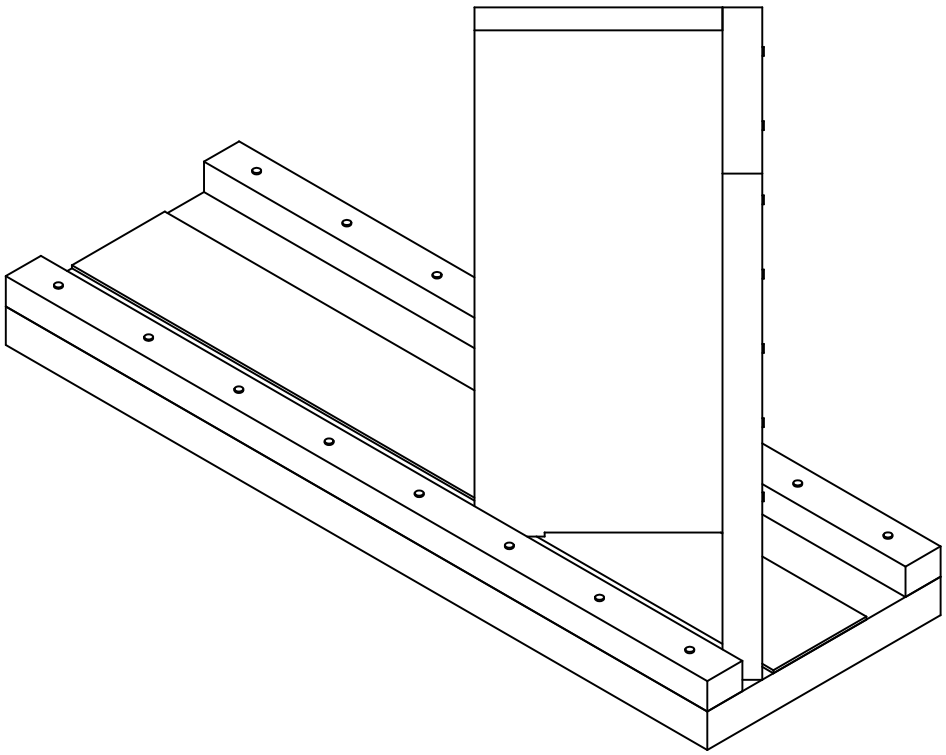
Chapter 3

Shaped Tools

Contents

In this chapter, I introduce the tools required to build all the machines described in this building plan. I present the **perpendiculator**—a tool used to make the ends or faces of a tube, or any part, perfectly perpendicular.

3.1 perpendiculator



Contents

In this section I introduce how to build the **perpendiculator**. This tool has two assemblies the **plane** and the **slider**. They have both a paragraph in which all details are explained. In the paragraph **Assemblies** the whole tool are assembled with the sub-assemblies **plane** and **slider**. And in the paragraph **Normalized parts** are showed all the normalized parts which are used for the **plane** and the **slider** (for example **wooden glue**, **nails**).

3.1.1 Roadmap

In this section we can find the roadmap to build the **perpendiculator**. It's not necessary to follow straight all these points after another, but I think it's the most logical to do it like this :

1. prepare all stuff in the **Parts-list** with the tools showed in the **Tools-list** ;
2. assemble the **slider** ;
3. assemble the **base**.

3.1.2 Parts list

In this section we can find the whole list of parts that the **perpendiculator** needs, like :

- 1x **base** size 133x400x19 in MDF ;
- 1x **rectangular-wooden-list** size 15x20x1000 in beech for :
  - 2x **guide**.
- 1x **sandpaper** ;
- 1x **face-1** size 100x250x16 in MDF ;
- 1x **face-2** size 116x250x16 in MDF ;
- 1x **nails** (box) size 1.4x30 ;
- 1x **wooden glue** ;
- 1x **amidon glue**.

3.1.3 Tools list

In this section we can find the list of tools that we need to build the **perpendiculator**, like :

- 1x hammer ;
- 1x drill press ;
- 1x 1.4mm diameter drill ;
- 2x clamps ;
- 1x ruler ;
- sandpager.

3.1.4 Shaped parts

In this paragraph we can find all the shaped parts of the **perpendiculator**, like :

- **base** ;
- **guide** ;
- **sandpaper** ;
- **face-1** ;
- **face-2**.

base

Here is shown the information for the shaped part **base**.

Roadmap

1. order in a carpentry.

That's all for this part.

Drawing See figure 3.1, page 81

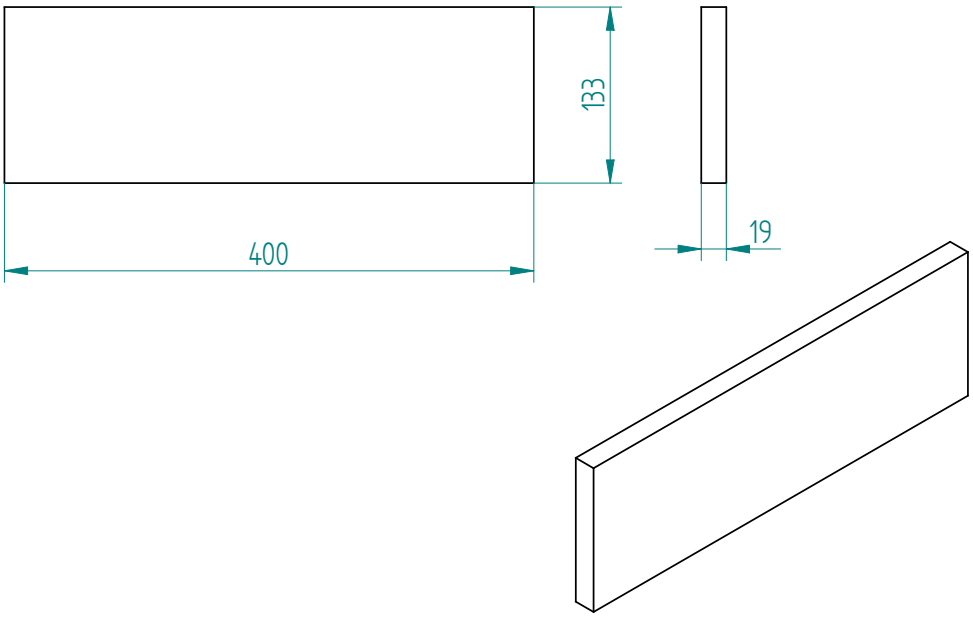


Figure 3.1: Shaped part : **base** for **perpendiculator** tool

quantity 1 ;

material MDF ;

provider carpentry ;

price ?.

guide

This section shows how to build the **guide** of the **perpendiculator** tool.

Roadmap

1. order the **rectangular-wooden-list** see section 3.1.5, 87 ;
2. ask at the carpentry to cut it at the good length (see the length on the figure 3.2, page 82) ;
3. drill the holes with diameter 1.4mm (see figure 3.2, page 82 for the positions).

Drawing See figure 3.2, page 82

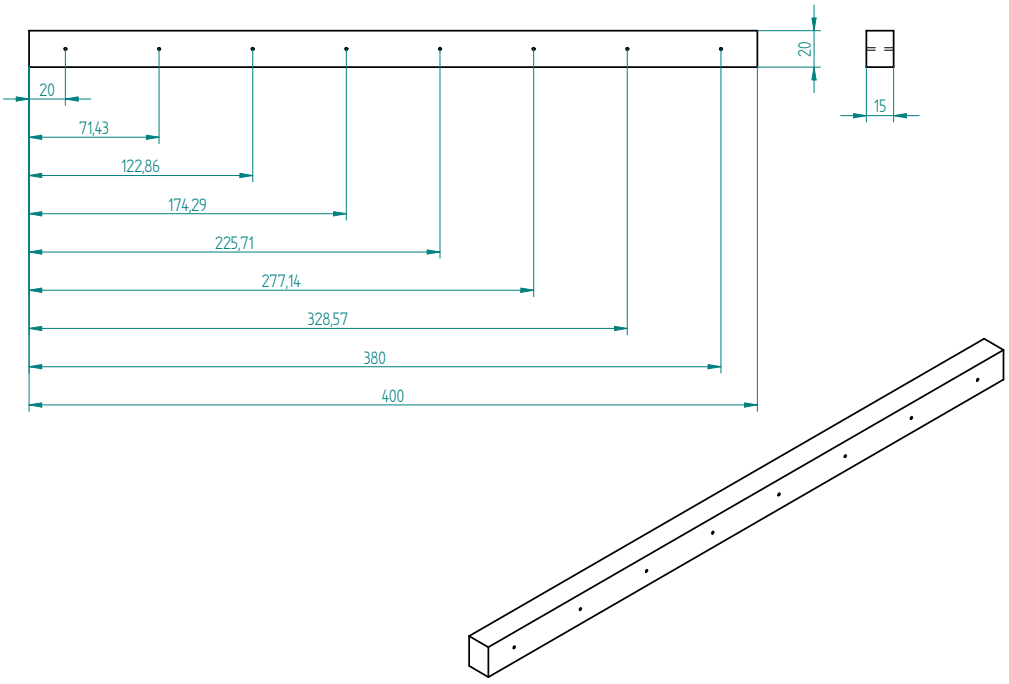


Figure 3.2: Shaped part : **guide** for **perpendiculator** tool

quantity 2 ;

material beech ;

provider ironmongery ;

price ? .

sandpaper

Drawing See figure 3.3, page 83

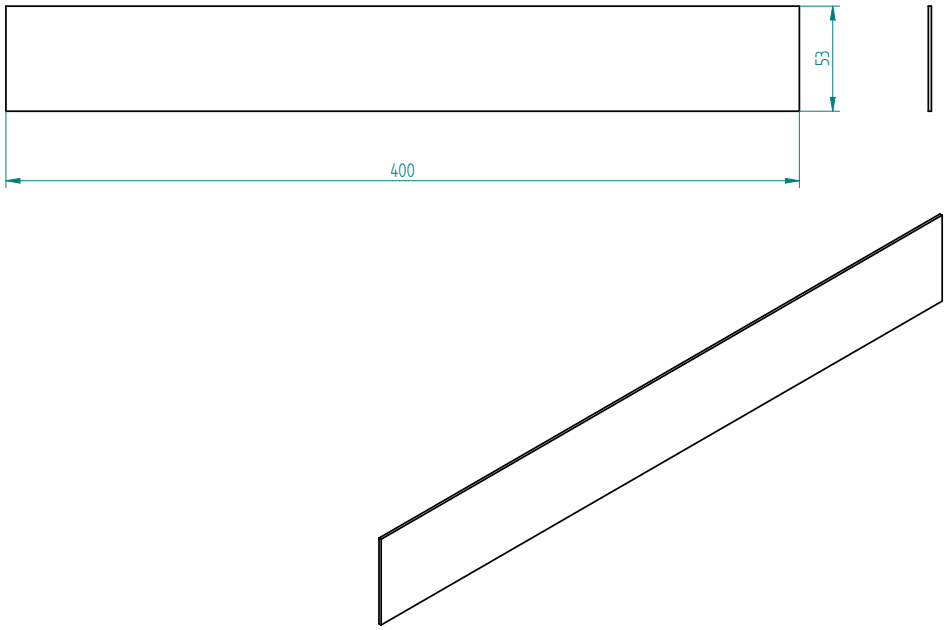


Figure 3.3: Shaped part : **sandpaper** for **perpendiculator** tool

quantity 1 ;

material emery granularity : 80 ;

provider ironmongery ;

price ?.

face-1

Roadmap

1. order the part in a joinery see figure 3.4, page 84 for dimensions.

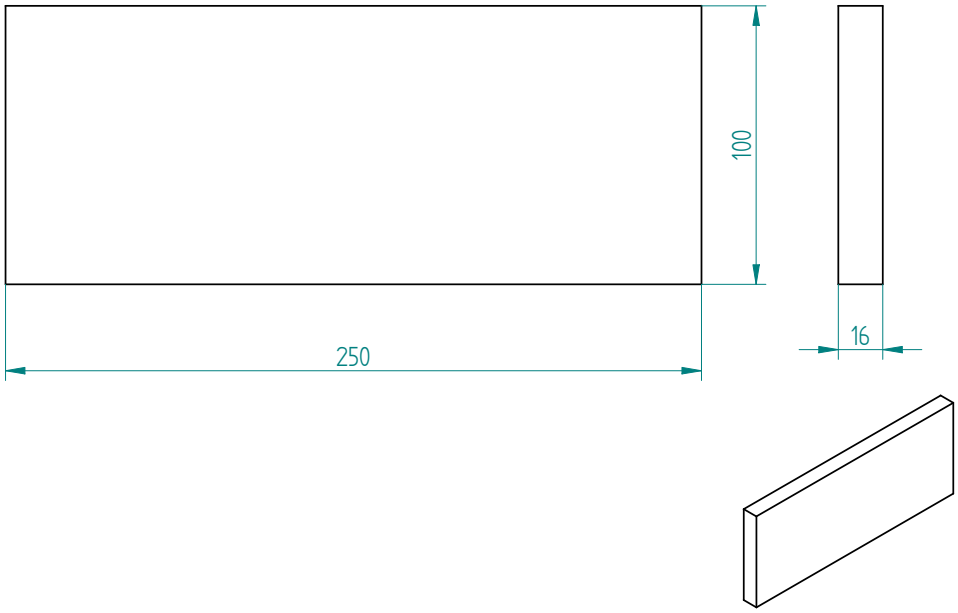


Figure 3.4: Shaped part : **face-1-outsourcing** for **perpendiculator** tool

Drawing This is how the **face-1** looks at the end. See figure 3.5, page 85

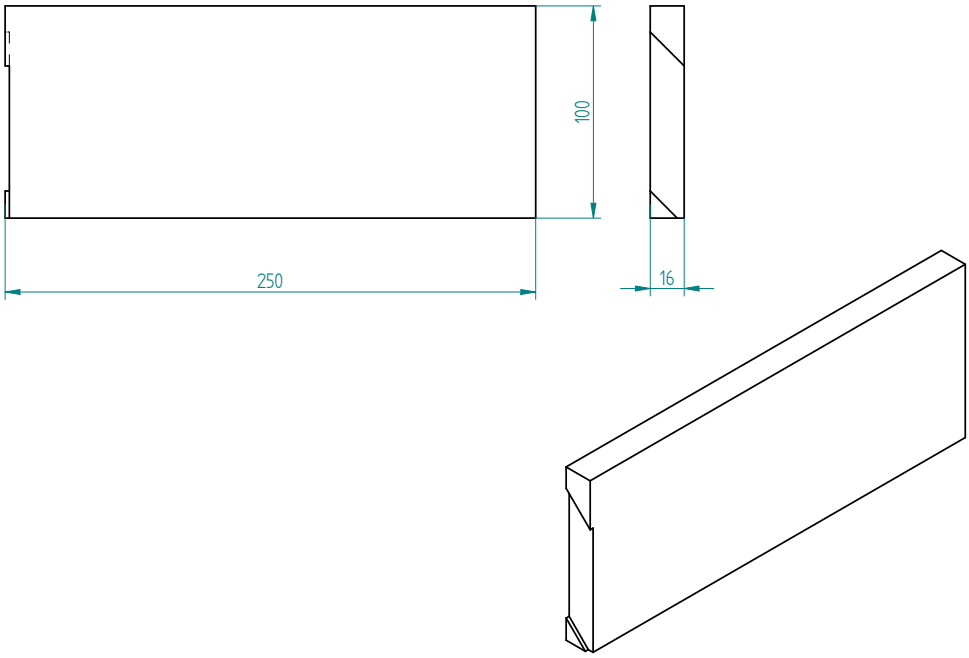


Figure 3.5: Shaped part : **face-1** for **perpendiculator** tool

quantity 1 ;

material MDF ;

provider joinery ;

price ?.

face-2

Roadmap

1. order the part in a joinery see figure 3.6, page 86 for dimensions ;

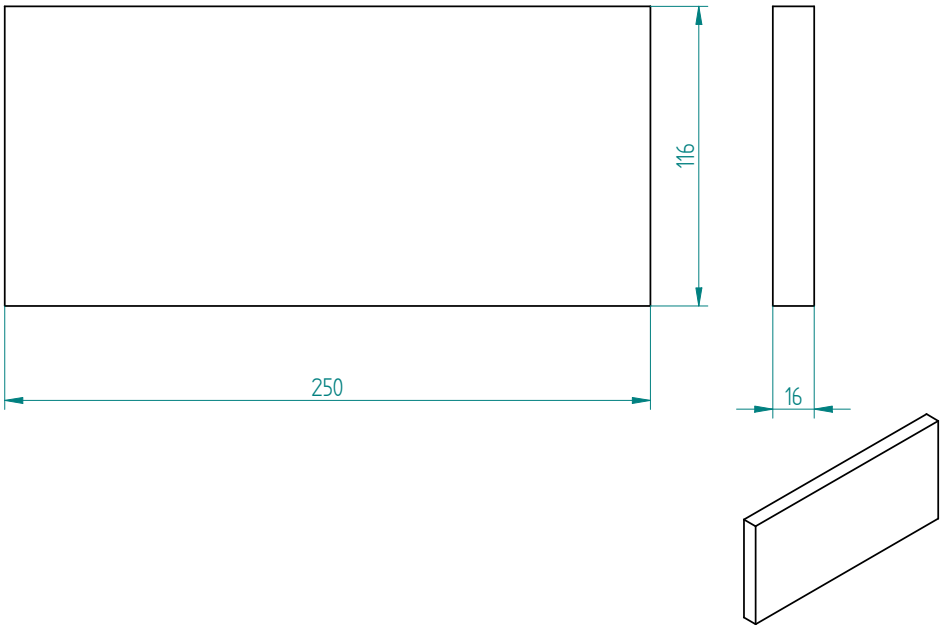


Figure 3.6: Shaped part : **face-2-outsourcing** for **perpendiculator** tool

2. drill the holes for dimension of the hole and positions see figure 3.7, page 87.

Drawing See figure 3.7, page 87

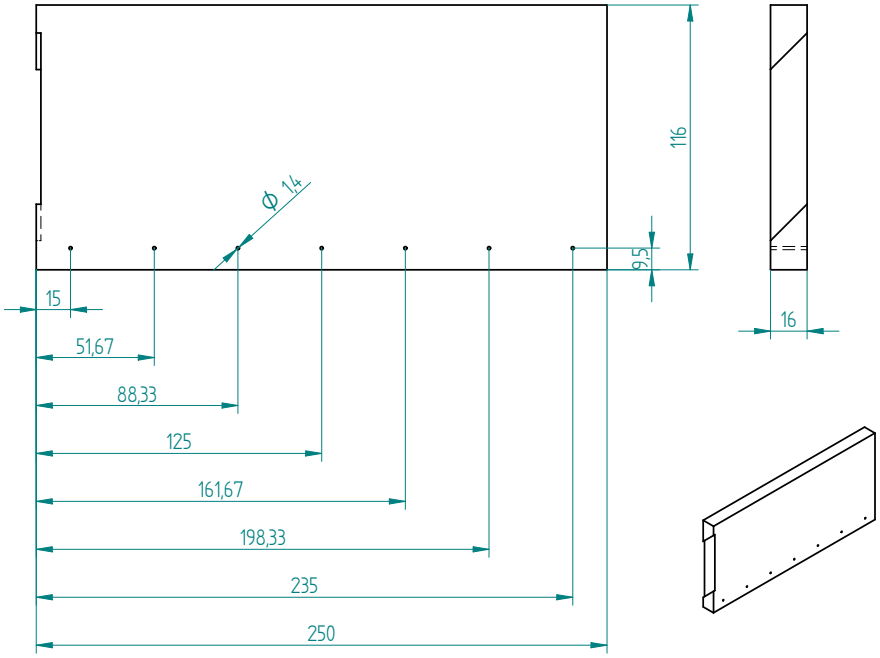


Figure 3.7: Shaped part : **face-2** for **perpendiculator** tool

quantity 1 ;

material MDF ;

provider ironmongery ;

price ?.

3.1.5 Normalized parts

In this paragraph the normalized parts of the **perpendiculator** are showed. Like :

- **sandpaper** ;
- **nails**.

rectangular-wooden-list

Here are some information of the **rectangular-wooden-list** which are used to build the **perpendiculator**.

Drawing See figure 3.8, page 88

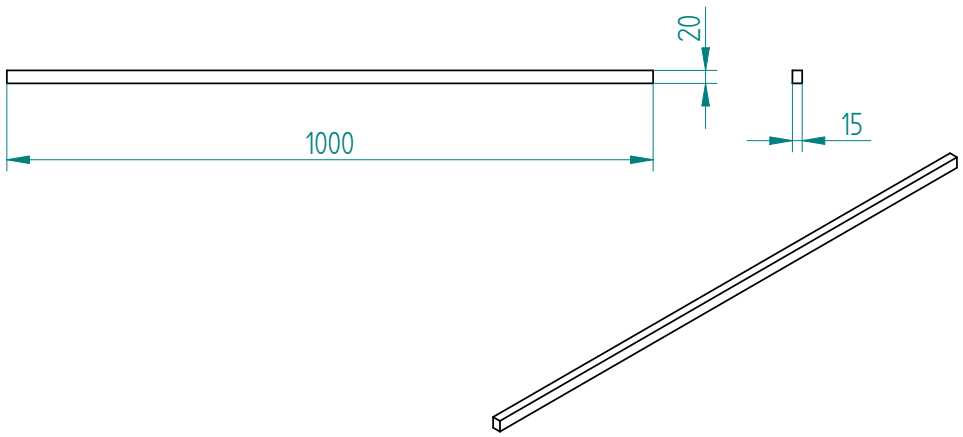


Figure 3.8: Normalized part : **rectangular-wooden-list** for **perpendiculator** tool

quantity 1 ;

material beech ;

provider ironmongery ;

price 5.20frs.

sandpaper

Here are some information of the **sandpaper** which are used for the **perpendiculator**.

Size ? ;

Provider any ironmongery ;

Price ?

nails

Here are some information of the **nails** which are used to build the **perpendiculator**.

Drawing See figure 3.9, page 89

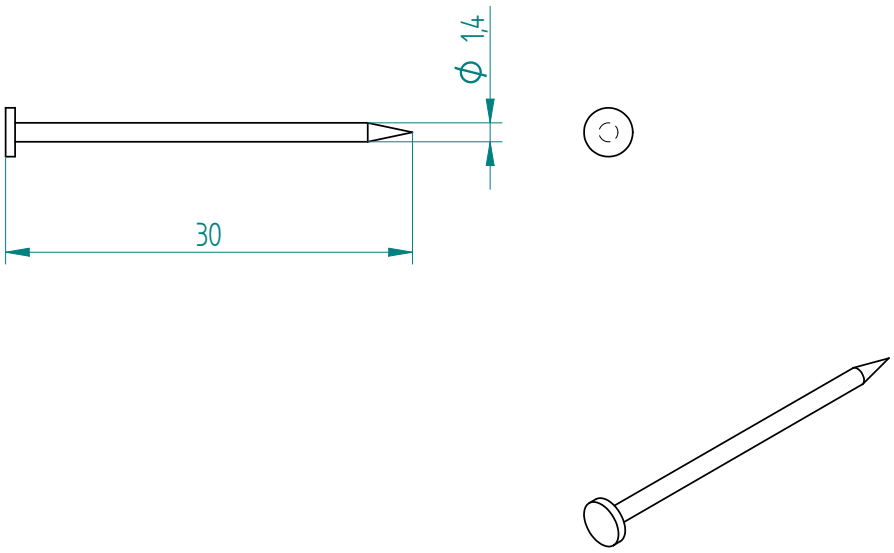


Figure 3.9: Normalized part : **nail** for **perpendiculator** tool

quantity 1 box ;

material steel ;

provider ironmongery ;

price ?.

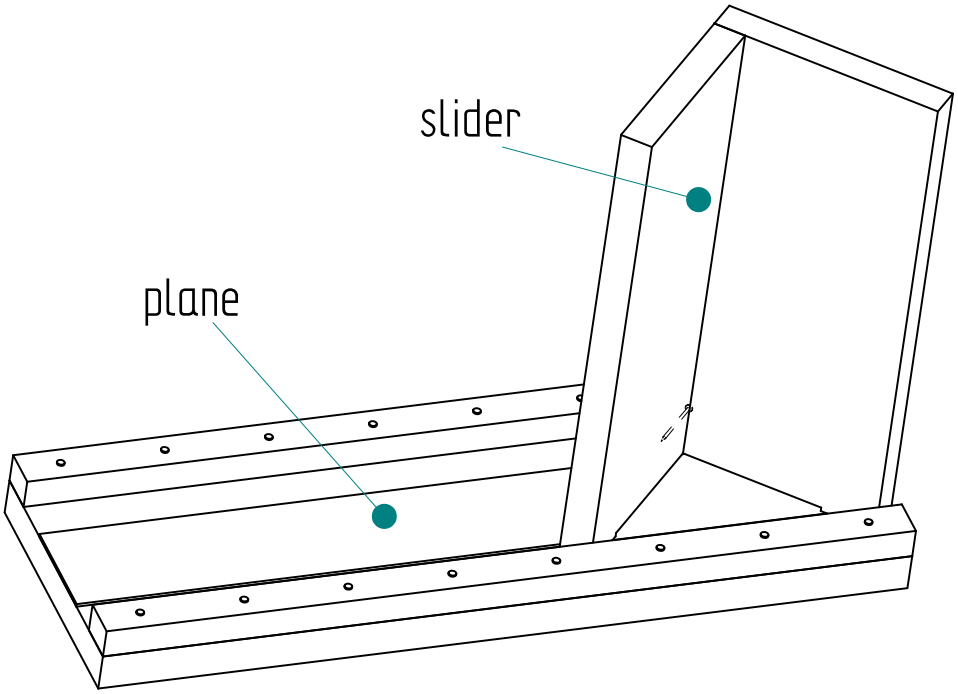
amidon-glue

quantity a bit ;

provider any ironmongery ;

price ?

3.1.6 Assemblies



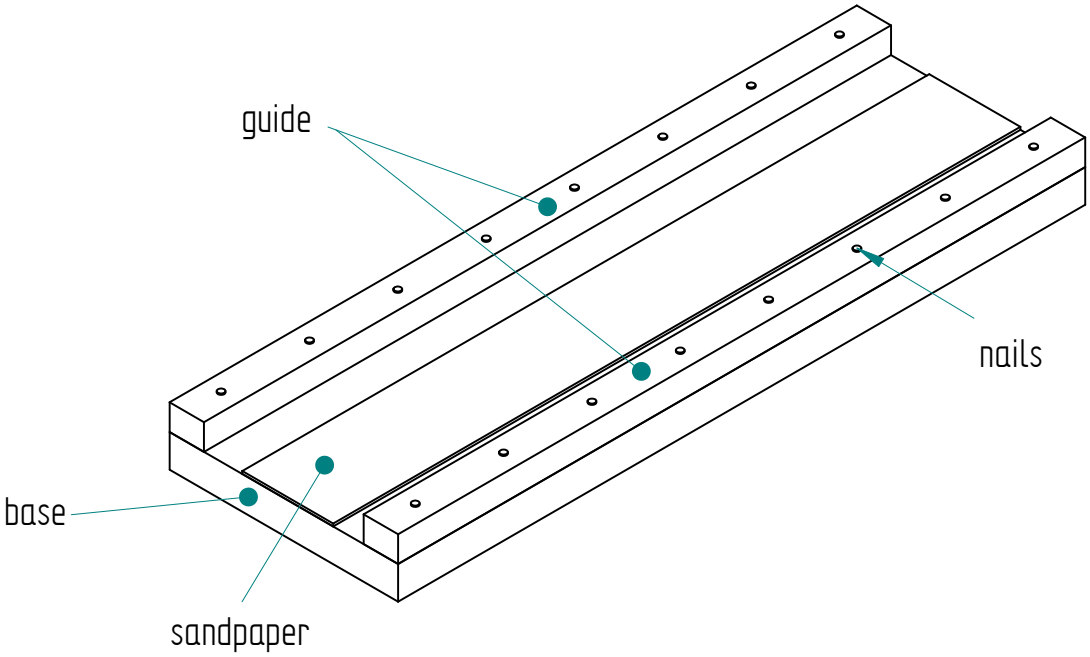
After built all the **Shaped-parts** and get all **Normalized-parts**, it's time now to assemble the sub-assemblies :

- **plane** ;
- **slider**.

Roadmap

1. assemble the **plane** ;
2. assemble the **slider** ;
3. assemble the **perpendiculator** with **plane** and **slider**.

plane



In this section we explain how to assemble the **plane** which is a sub-assemblie of the **perpendiculator**.

Worldmap

1. with **amidon glue** glue the **sandpaper** at the right position (see figure 3.10, page 92) ;

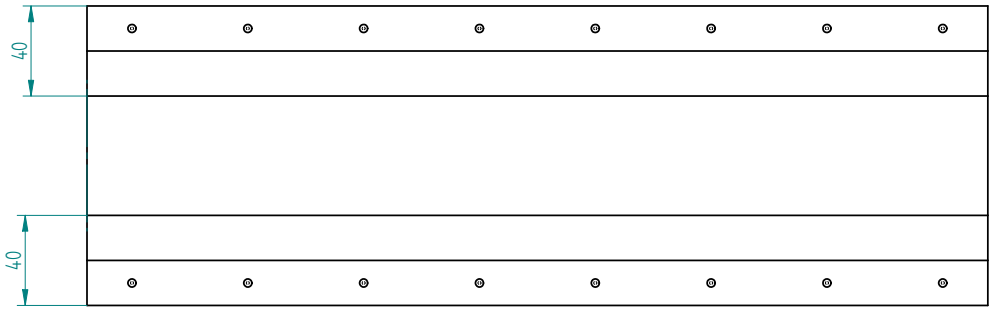
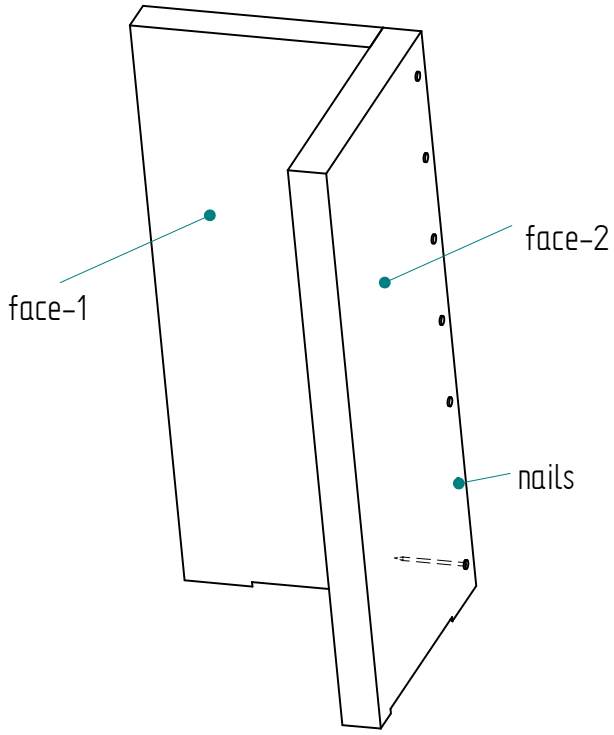


Figure 3.10: position of the **sandpaper** on the **base**

2. align the **guide** to the edge of the **base** ;
3. once well aligned, **clamp** with two **clamps** ;
4. put the **nails** in the holes of the **guide** ;
5. hammer the **nails** maybe 2 or 3mm inside the **base** ;
6. make a mark to know the direction of **guide** on the **base** ;
7. remove the **clamps** and the **guide** from the **base** ;
8. put some **wooden glue** on the **guide** ;
9. then align the **guide** with the holes made with the **nails** in the **base** ;
10. hammer the **nails** deep into the **base** to tight the **guide** ;
11. repeat these steps for the second **guide** ;

slider



In this section we explain how to assemble the **slider** which is a sub-assemblie of the **perpendiculator**.

Worldmap

1. put the **nails** in the holes of **face-2** ;
2. align the **face-2** on the **face-1** ;
3. press both parts with a **clamp** ;
4. hammer the **nails** 3 to 4mm into the **face-1** ;
5. remove the **clamps** and unjoin **face-1** and **face-2** ;
6. put some **wooden-glue** on the **face-2** ;
7. join both part again taking care that that the **nails** go into the hole of 3 to 4mm depth done at the previous point ;
8. hammer the whole length of the **nails** so that both parts are pressed for glueing.