PHABLABS 4.0

PHOTONICS WORKSHOP

BATMAN PORTABLE TORCH

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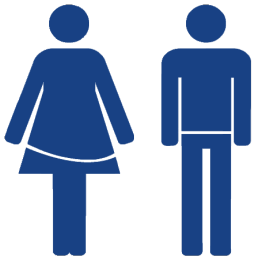
PROPERTIES OF THIS WORKSHOP

SUMMARY:

Build a torch that projects your personalized design!

Build a torch and personalize it with a stencil designed by you. Construct the electrical circuit and build it into a 3D-printed case. In this workshop, you will learn about lenses and how these help projecting images, and how to build a torch from scratch, including electrical circuits and installing LEDs.



TARGET AUDIENCE:

Young students (10-14 years old)

SUGGESTED TIME PLANNING: (Total: 1,5h, 3D printing upfront)

Timing in minutes	**activity**
0-10	Introduction lenses
10-40	Soldering electronics
40-50	Assembling torch
50-70	Drawing design for vinyl + vinylcutting
70-90	Playing

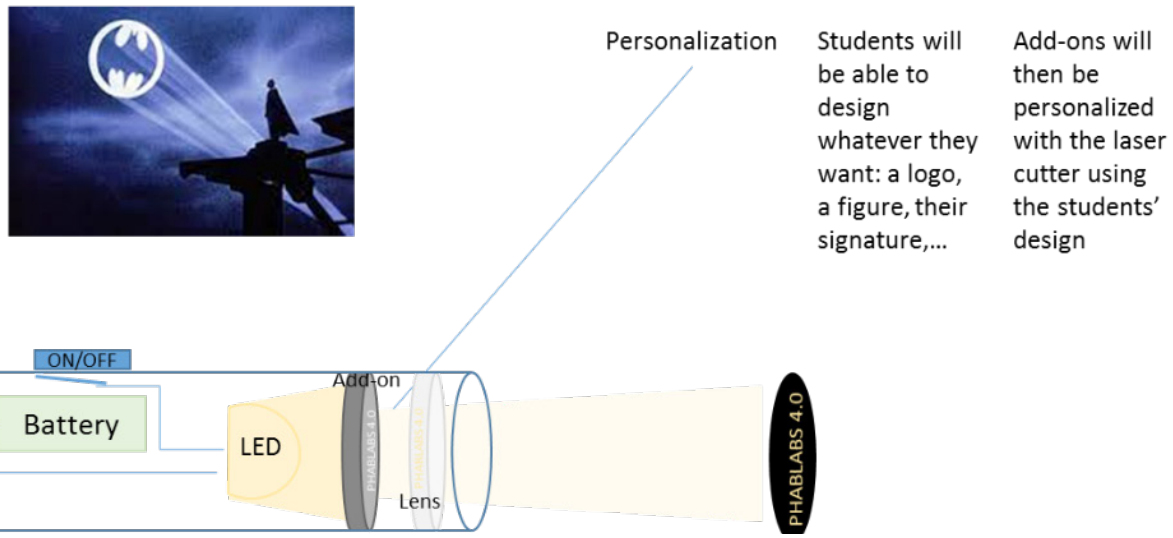
TOOLS:
3D printer
Milling machine (not necessary)
Soldering iron

WEBLINK:

All needed files for lasercutting andWemos can be found on:
http://www.phablabs.eu/workshop/batman-style-portable-torch
or via the QR code.

Step 1: Convex lenses & focal lengths

Kids will learn to build a torch that will incorporate a personalized add-on and a lens so that its shines likte the batman light.



The principle behind this Batman portable torch is based on **the technology of convex lenses and focal lengths**.

Participants will learn 3 main things:

1) *Photonics: use, types and printing of lenses*
2) *Electronics: basic circuit design and creation*
3) *Core tools in a makerspace: 3D printing and milling machines*

Convex Lenses & Focal Lengths

Lenses are everywhere. Take a look around and see how many people you can spot wearing spectacles. Think about how many you can't spot wearing contact lenses. So what makes a lens?

A lens is a piece of glass or firm transparent material that curves in such a way that it redirects light. There are two main types of lenses: **convex and concave**.

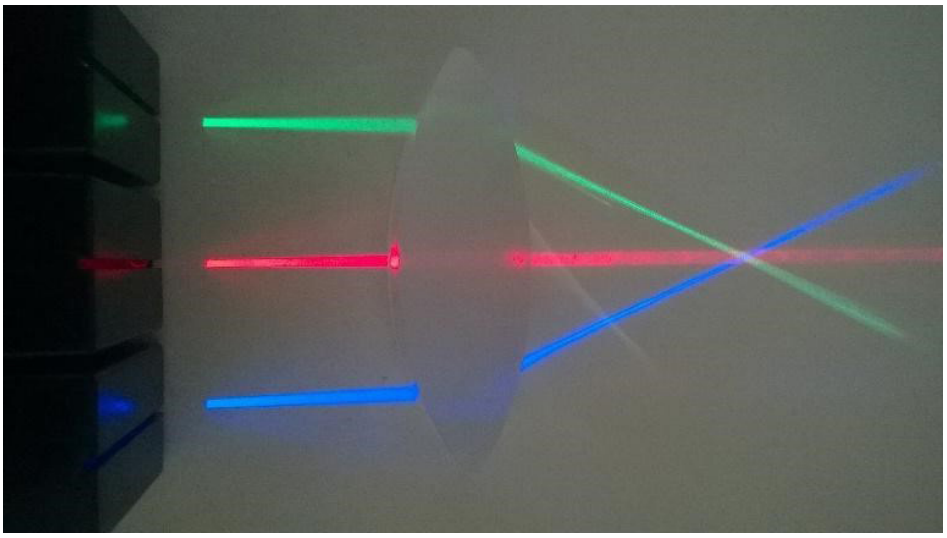


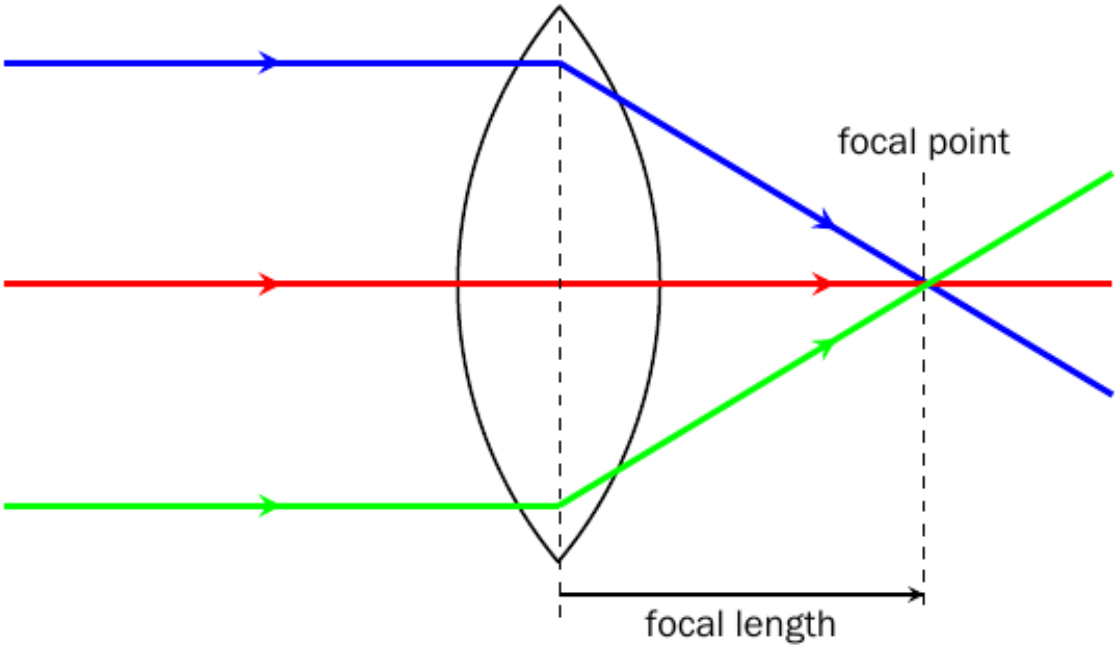
Figure 1: Light rays through a Convex lens.

Convex lenses are thicker in the middle than at the ends. Take a look at Figure 1. Here, three rays of light are shining through a convex lens. When they enter, they're all shining straight ahead. As they pass through the lens, however, **refraction** causes the rays on the ends to bend inwards, towards the lens. This is because the glass of the lens is denser than the air around it.

A convex lens is also called a converging lens because it makes parallel light rays passing through it bend inward and meet (converge) at a spot just beyond the lens known as the focal point. The distance from the centre of the lens to the focal point is called the **focal length.** Figure 2 shows how the focal length is measured.

Not every convex lens has the same focal length, though. **Thinner** convex lenses have **longer** focal lengths. This is because the thicker the lens is, the more it bends the light, so the closer the focal point is to the lens!

Convex lenses are used in things like telescopes and binoculars to bring distant light rays to a focus in your eyes.

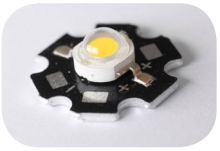


Focal length of refracted rays.

Step 2: Parts list

Collect all materials for each participant.

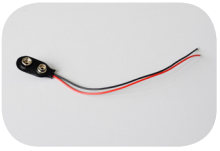
Photonics Parts:



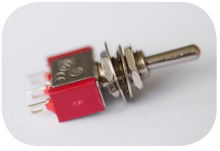
3W LED

Electronic Parts:

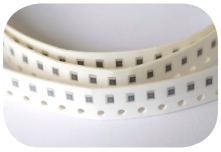
PCB FR-4 Single Sided



Battery snap



Toggle switch



Resitor (311-1.00KRFCT-ND)

Other Parts:

9V battery

Vinyl

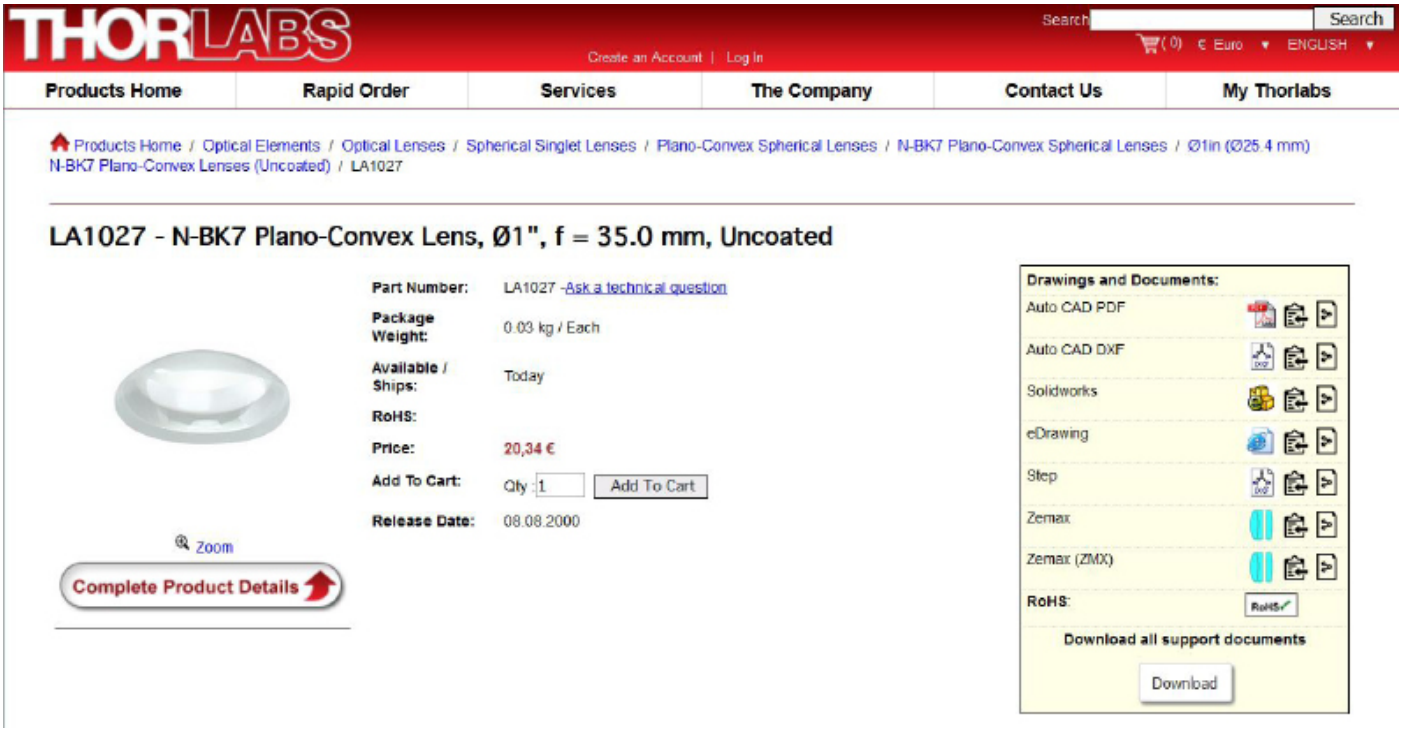
The photonics parts can be bought by EYESTvzw.
The electronic parts can be bought by Fablabfactory.

Download all the software, parts and find information here. An index list of suppliers and components:
-Thor Labs
-Form Labs 2
-Preform
-Onshape
-Rep Rap BCN
-Cura
-Inkscape
-Fab Modules
-Roland MonoFab SRM - 20
-V panel
-Roland Vinyl Cutter

Step 3: Download the Lens

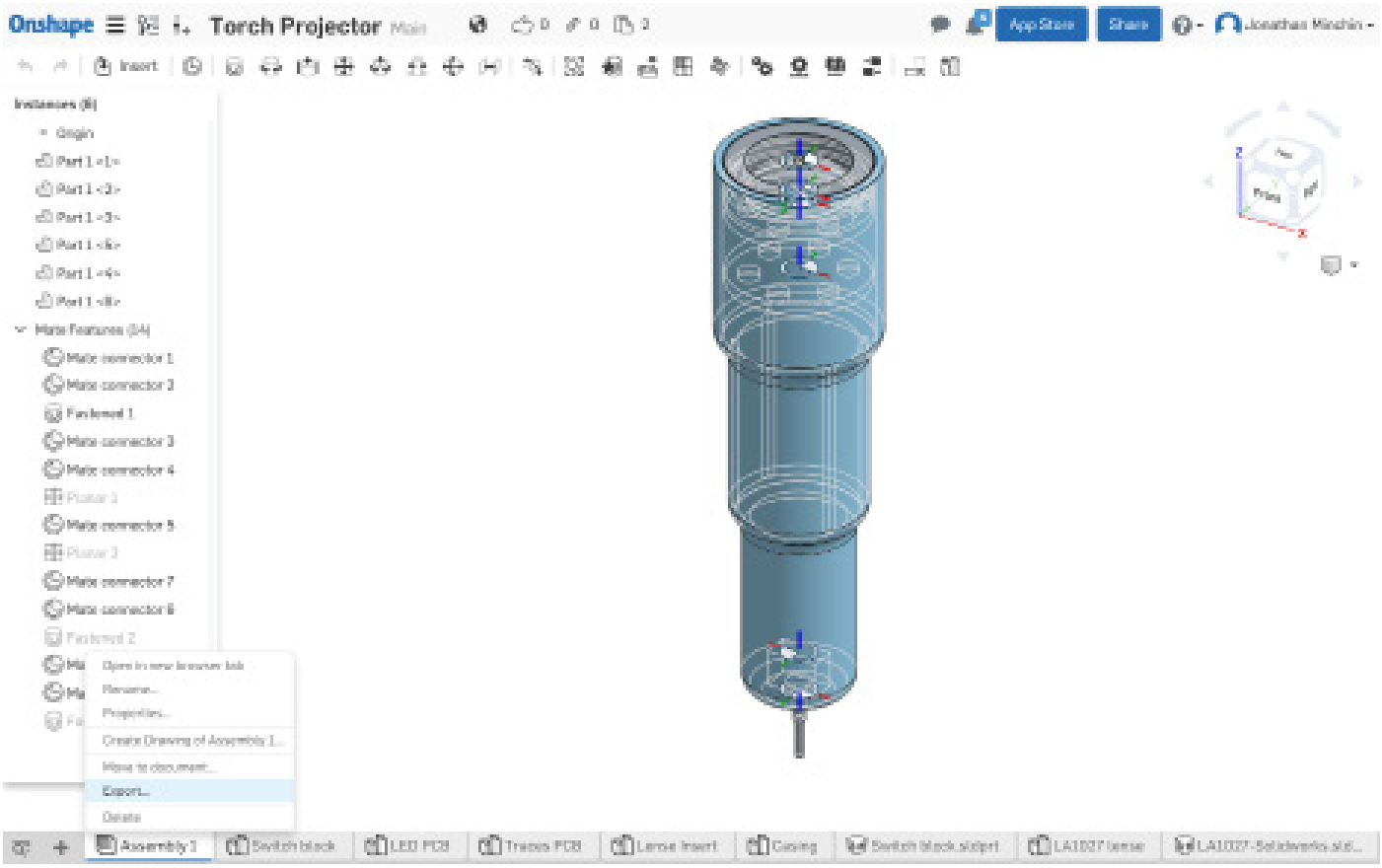
The following step explains how to what you have to do first. Go through each step with the participants.

The lens of the light torch is the main active component. We are using a Form Labs 2 resin based printer to do the prints with clear resin but first we need a file to print. Luckily the Thor Labs website offers lenses in a variety of downloadable 3d formats for free. For the Light torch we will be using a convex lense with the number LA1027. You can search the website for preview to find the downloads pages.



You will find lots of different 3D file types for the lens which you download, these load into 'CAD software' but are not yet ready for a 3D printer 'CAM software'. We have used some free software to help convert those files into a format ready for a 3D printer: Onshape is a platform that lets you design and share things in the browser online. We have already uploaded the lens to the model page here : Onshape - Light Torch.

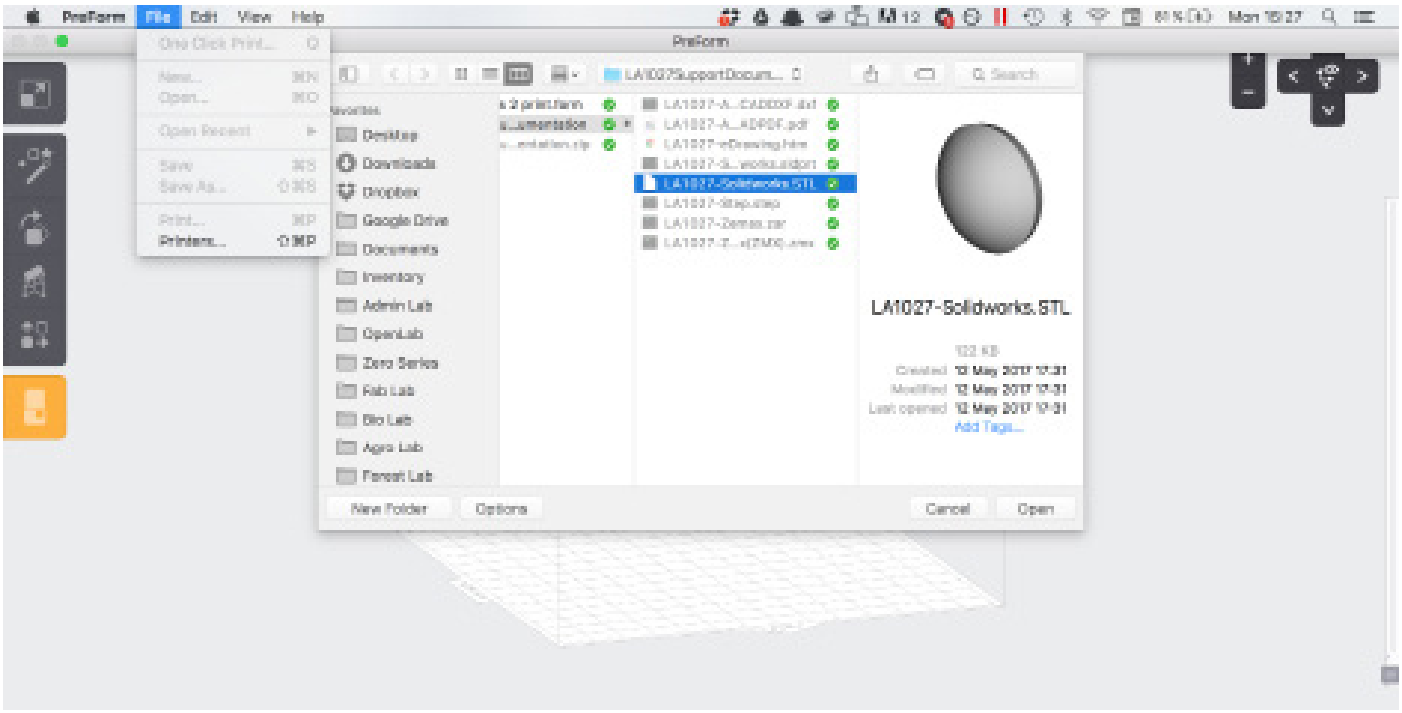
You can right click on any component in the model to export it. You will need an STL (Stereolithography) file to load into the CAM software



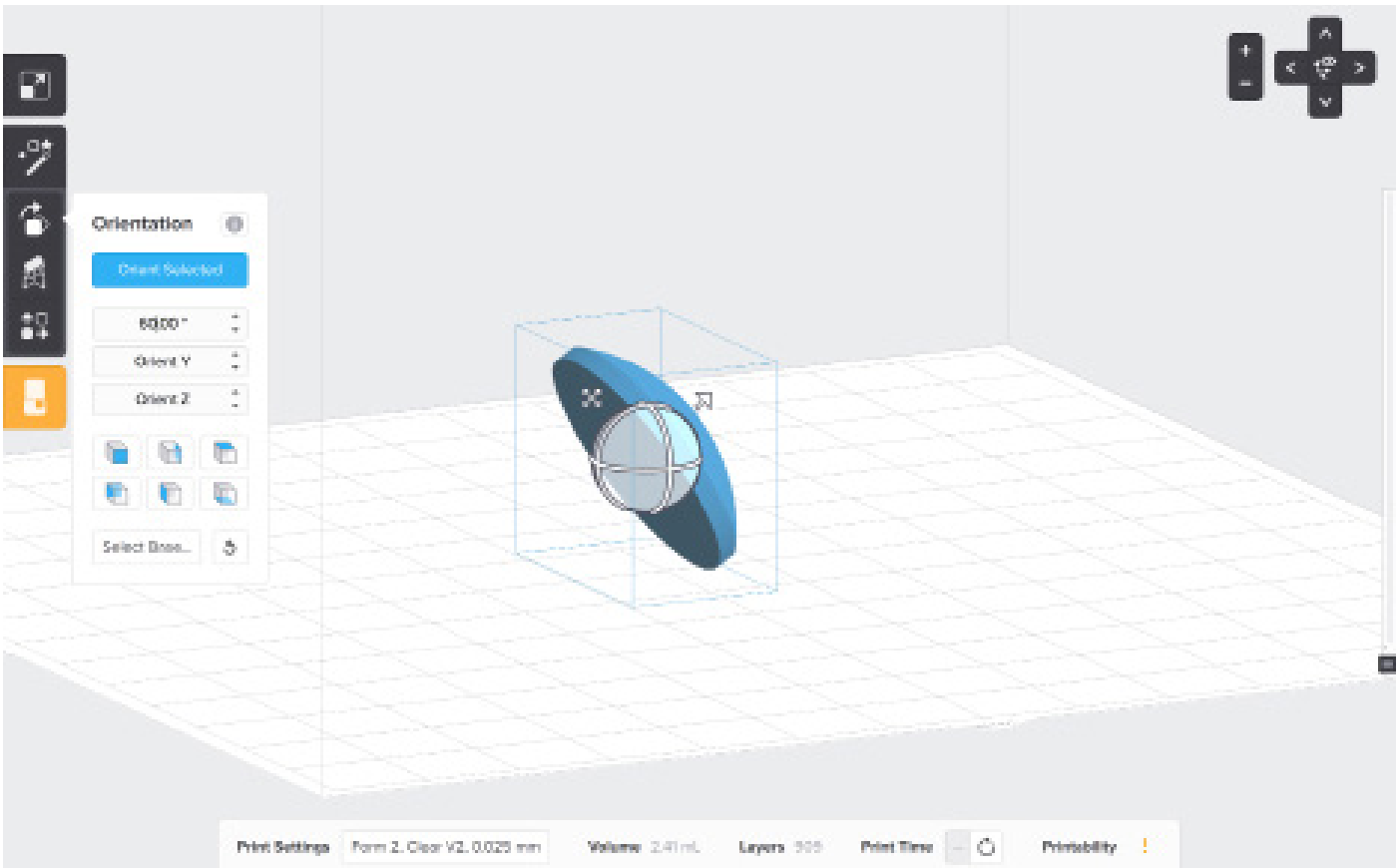
Step 4: Prepare the STL print file

Next is to setup the 3d model of the lense in the 'slicer' software for the form labs printer. The software is called 'Preform' and works by slicing a model into layers that the printer can use to recreate the digital model in resin step by step. Preform is free and works on most operating systems.

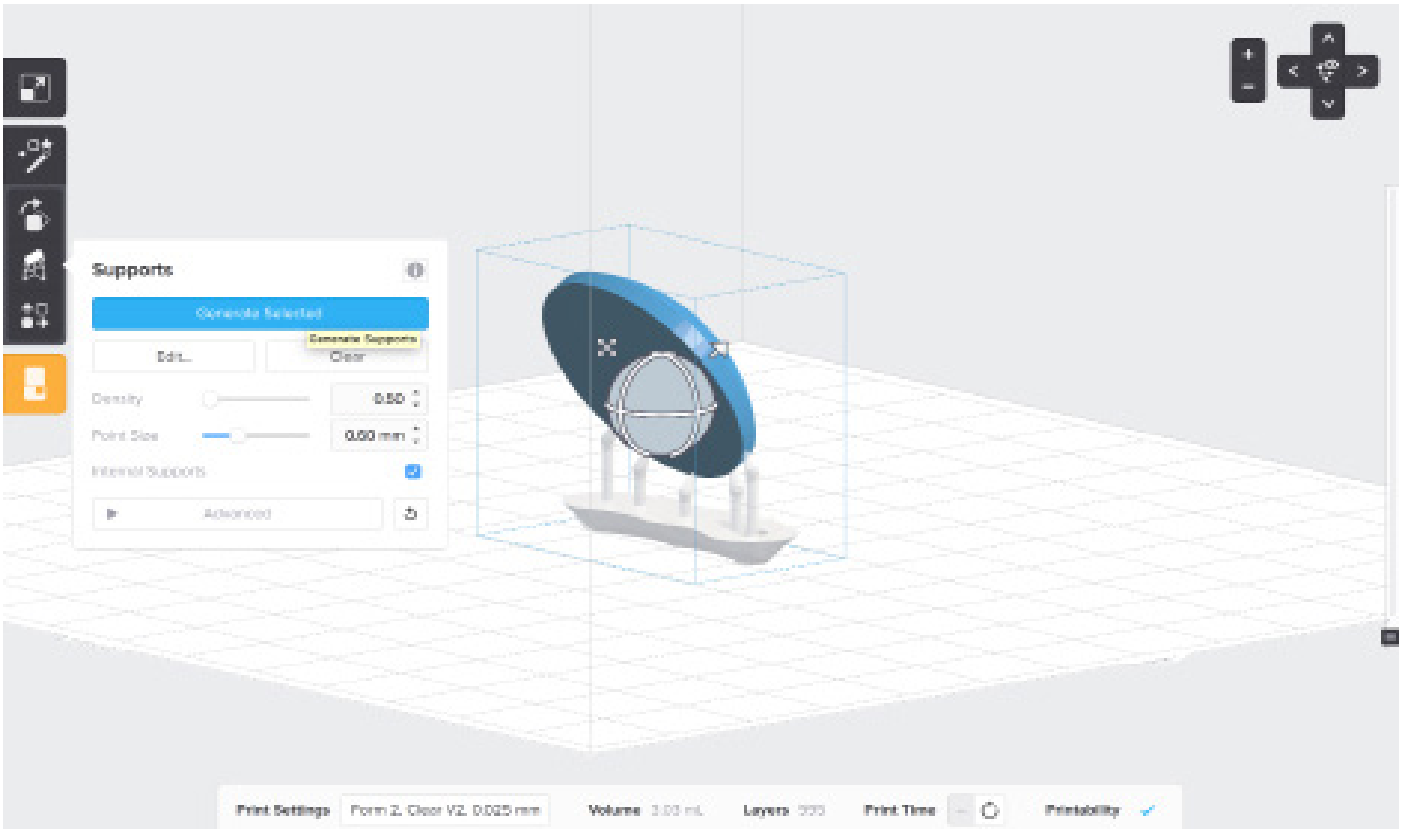
After Installing Preform and connecting your computer to the printer we must load in the model and design a build platform to hold the object whilst it is being printed.



Once the model is loaded into the software you have varied options for adjust its orientation and prepare it to print with supports. Use the rotate, move and magic prepare buttons to help you.



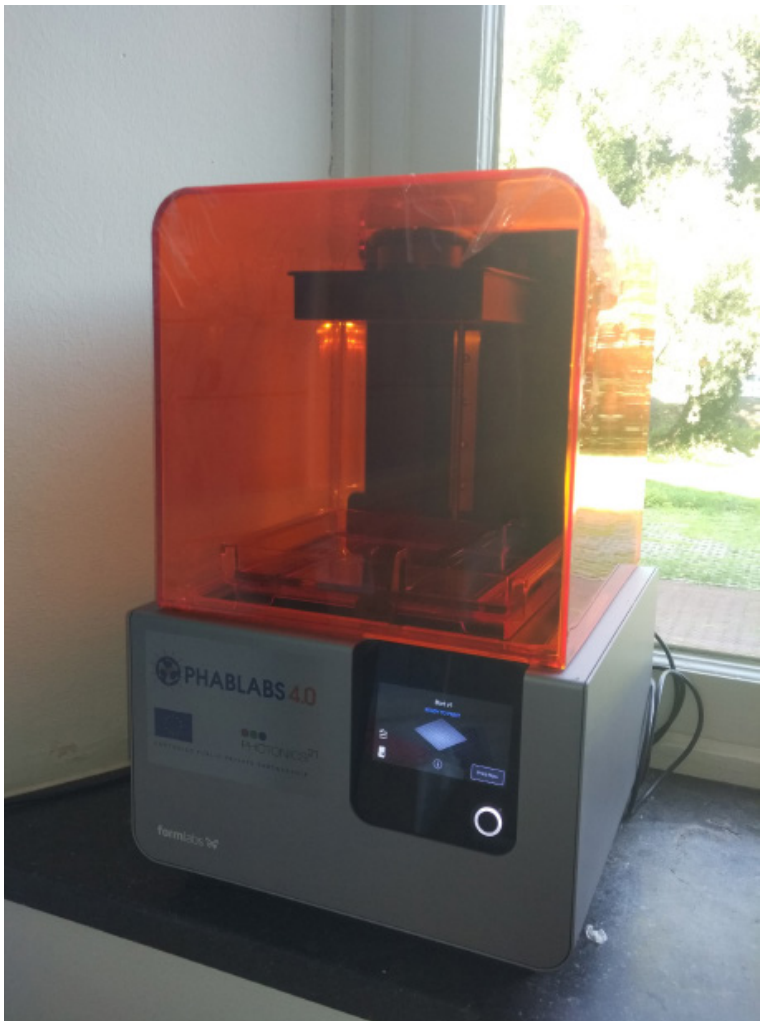
Each object is different so this process is both art and a science. We have tried to build as much support for the lense as possible, but avoiding support points touching the faces of the lense. Also positioning the lenses longest side parallel to the build platform will reduce the number of layers needed to print and will speed up the print.



Step 5: Printing the lens

The Form Labs 2 printer is a STL (Stereolithography) Resin based printer that works by projecting a laser onto a photoreactive layer of resin. The Resin solidifies on contact with laser, the model can then be built up in steps of layers. All of the instructions for setting up the printer and connecting it to your computer are found in the online instructions.

Tip: The Form Labs 2 printer is extremely simple to use and setup. But once you have installed everything and ready to receive the print make sure that you have left the cap of the resin open, remember also to close it after the print is finished. The print will take some hours, this is obviously faster than the months Galileo spent cutting and polishing glass to achieve a similar effect.



Once the print has finished you should extract it from the build plate in the cleanest and safest way, there are very thorough instructions on the Formlabs website. You will need to dip the print in isopropyl alcohol to clean it before being able to touch or polish it. Remember to use the protection gloves provided.

VIDEO : Form Labs printing.

Step 6: Polish the lens

When the lens is dried and cured from the Resin Printer, it is important to polish the surface to a fine degree. Always it is good to go form a coarse grained abrasive to a finer grained abrasive. There are several methods and ways to do this. Here is what worked for us:

Method 1 : Use a Micro drill with a leather head and buffer agent.

We used a Proxon drill with a buffing head and bugger agent as an abrasive to remove most of the tarnish on the lens. Remembering to use gloves and safety glasses. The lens can be safely positioned in a vice. Move the drill in circular motions around the lens face until it is of a uniform polish.

VIDEO : of Proxon with a Buffing Agent

Method 2 : Use a chemical liquid buffing agent with cotton buds.

This agent should reduce the surface to an even finer finish. Use a similar circular motion around the faces of the lense with the chemical agent until they achieve a uniform polish.

Alternative lens (commercial)

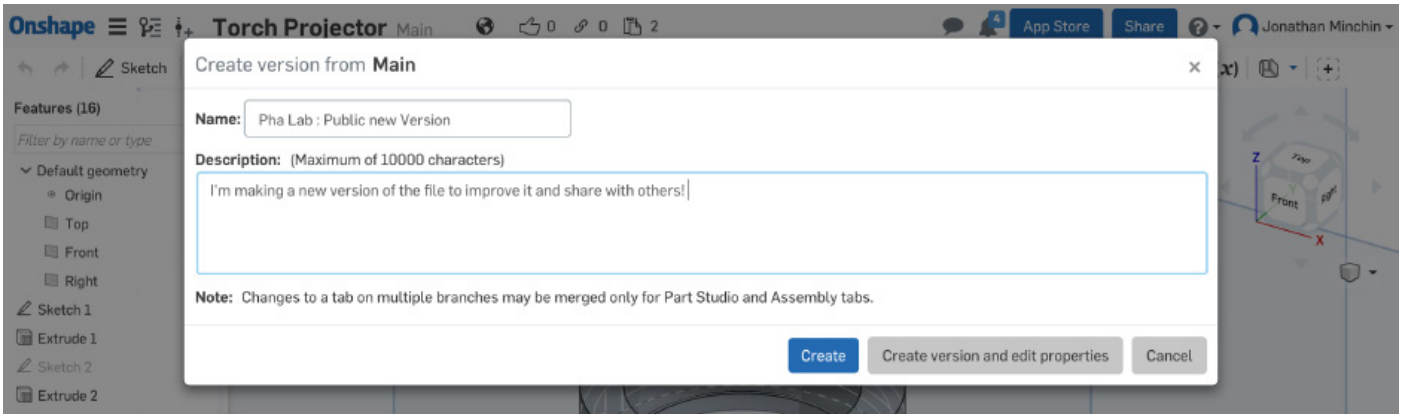
If you do not have a 3D printer resin base, you can use acrylic lenses.

Specifications:

Lens type: C
Diameter: 35.5 mm
Focal length: +170.0 mm
No 309.OM.7a

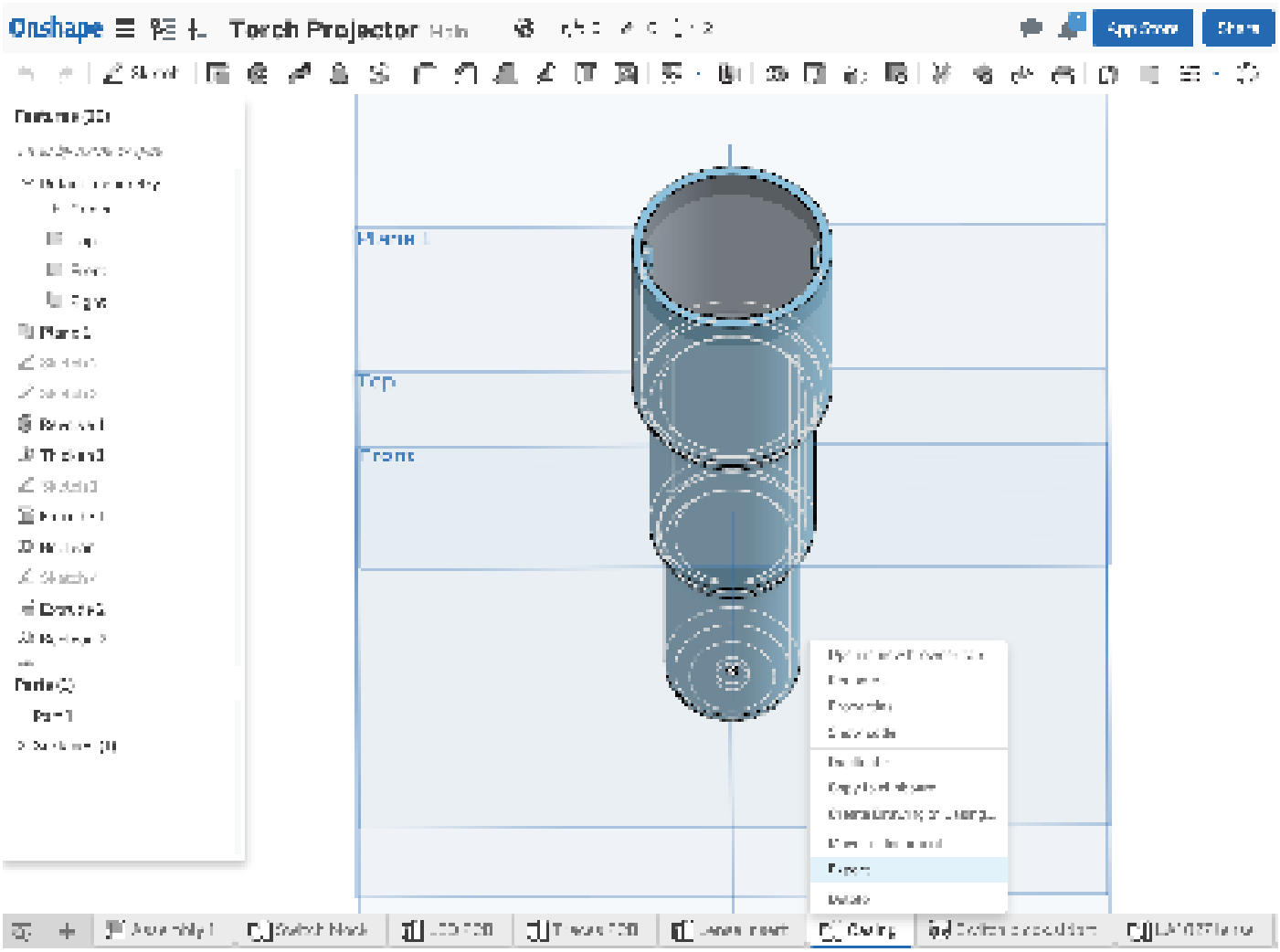
Step 7: Download the casing

NOTE : We have designed the case components using the Free online platform called Onshape. This is a very powerful software that allows users to edit designs. If you want to make your own version of the case, or modify it, you can! If you make your own account you will be able to simply 'Fork' a new version from our own files. Forking is a way of creating a new version that allows everyone us track changes and collaborate to improve the design.

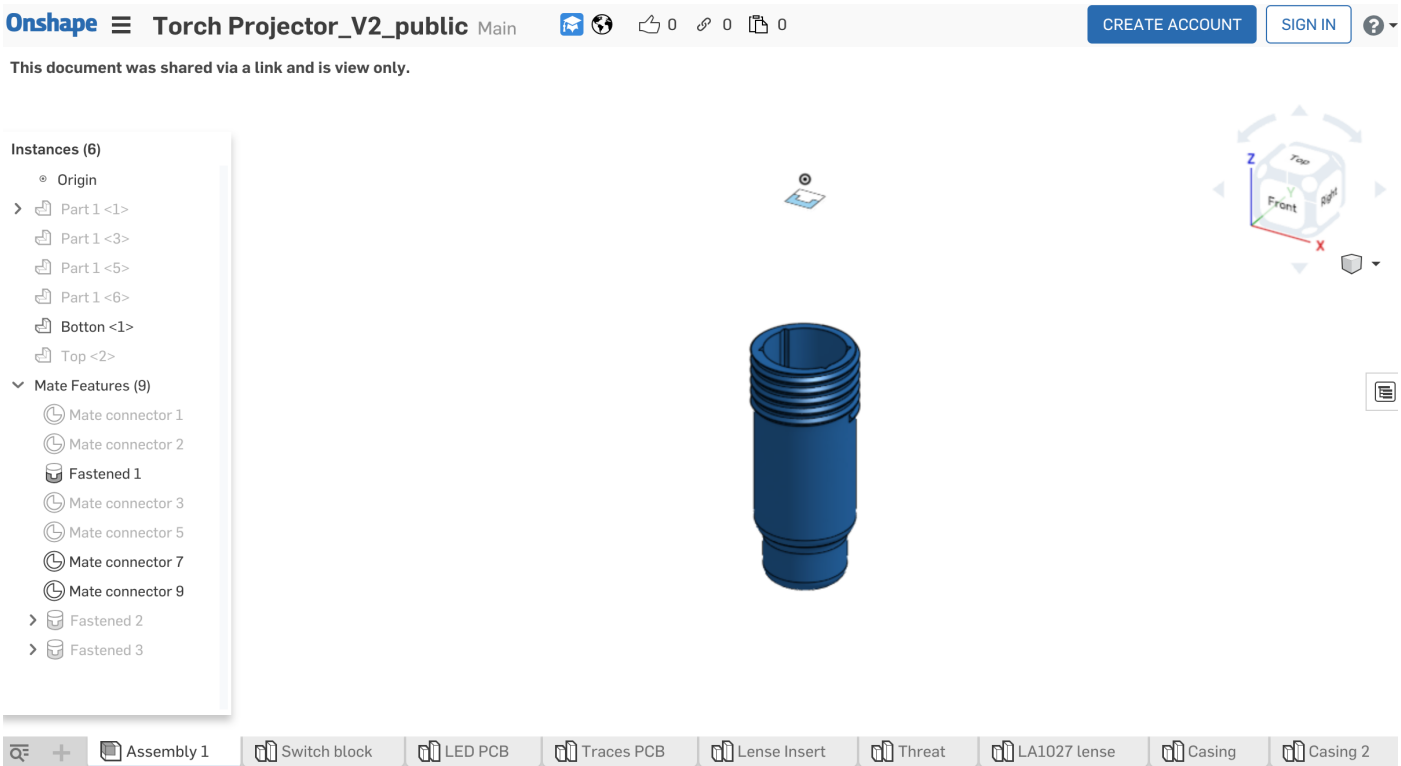


You can download any of the components using the same process as that for the Lens from this repository : Onshape - Light Torch. There are two components that need to be printed:

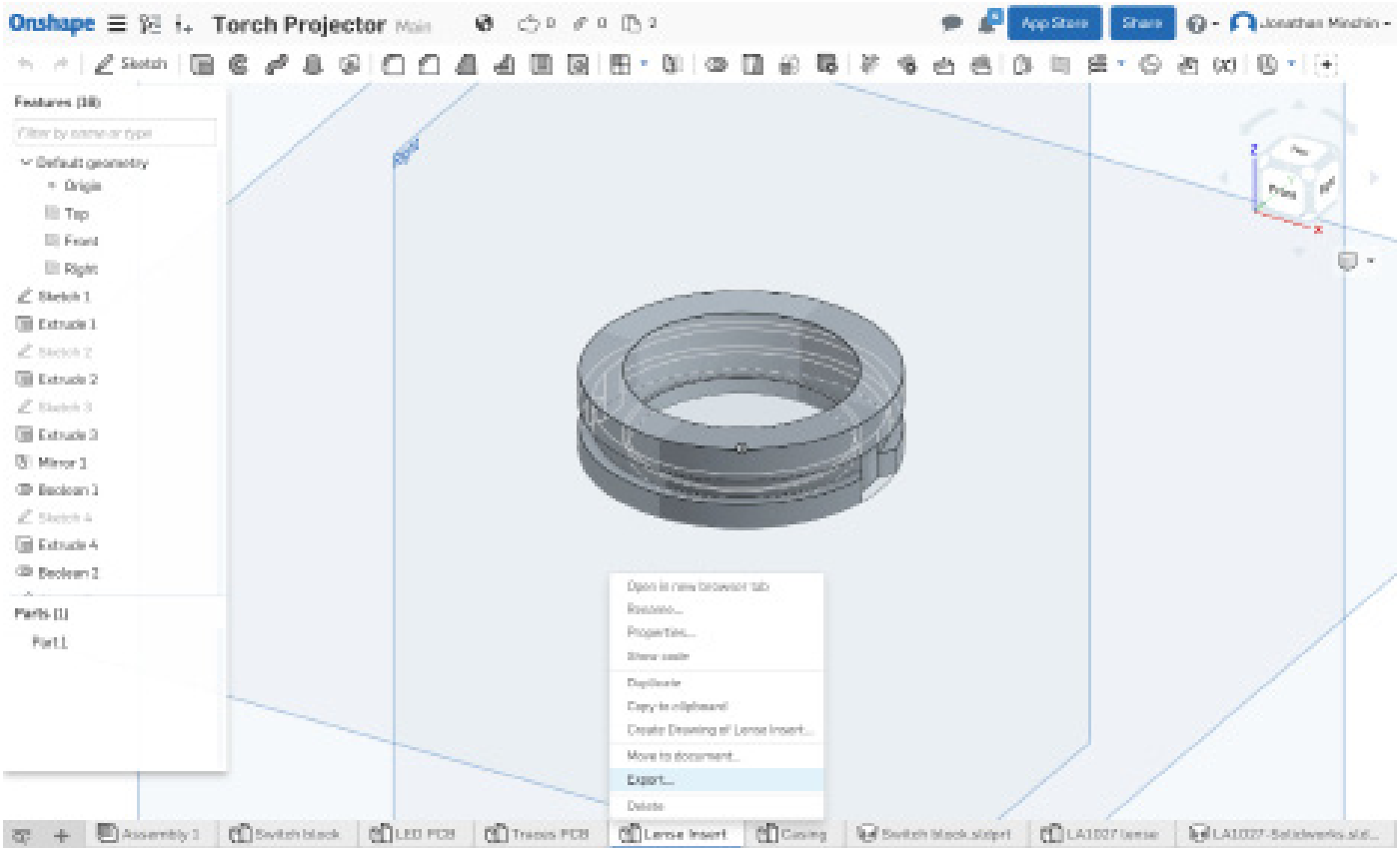
Print 1 : Casing



Print 2 : Casing bottom



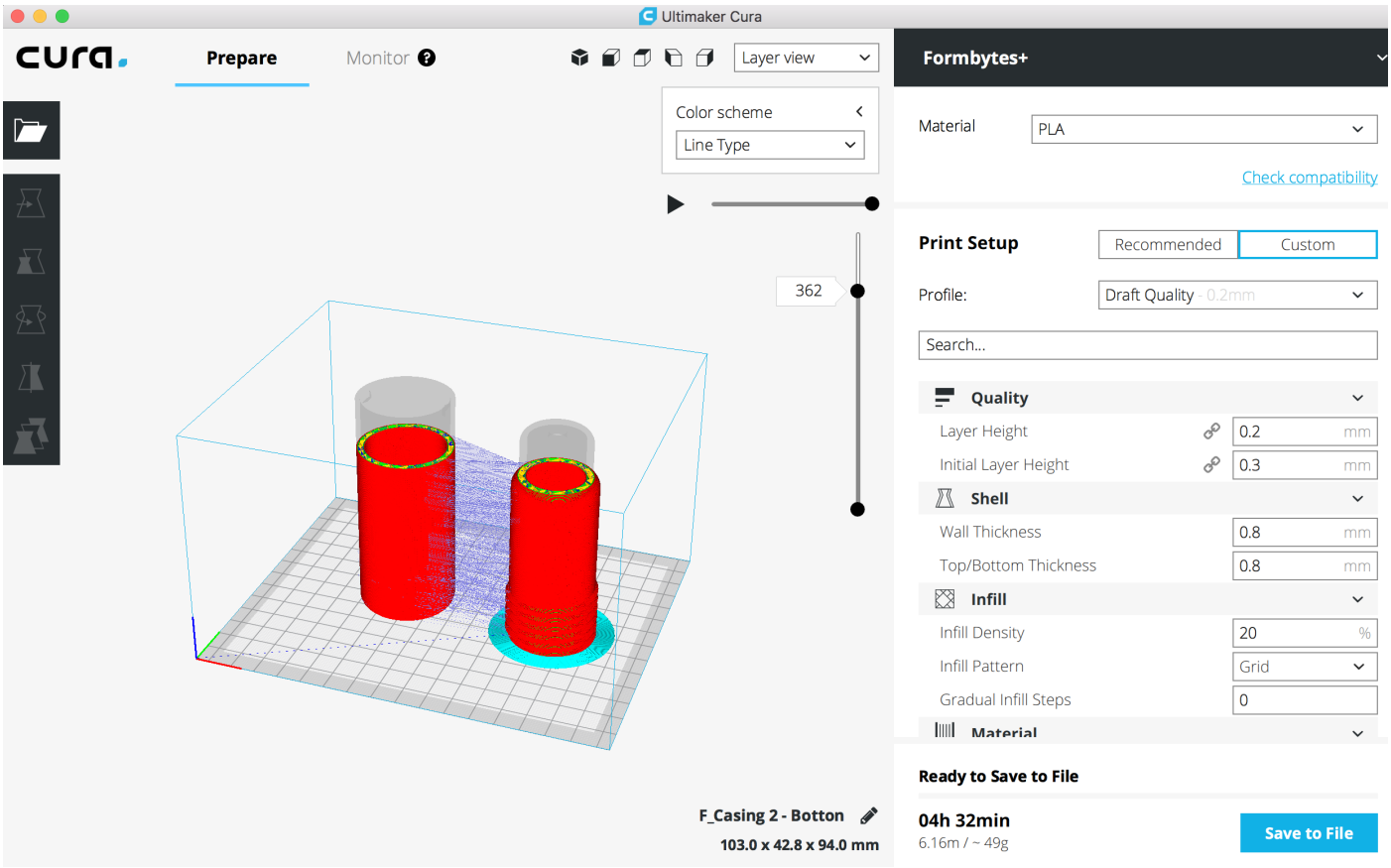
Print 3 : Lens Insert



Step 8: Prepare the FDM print file

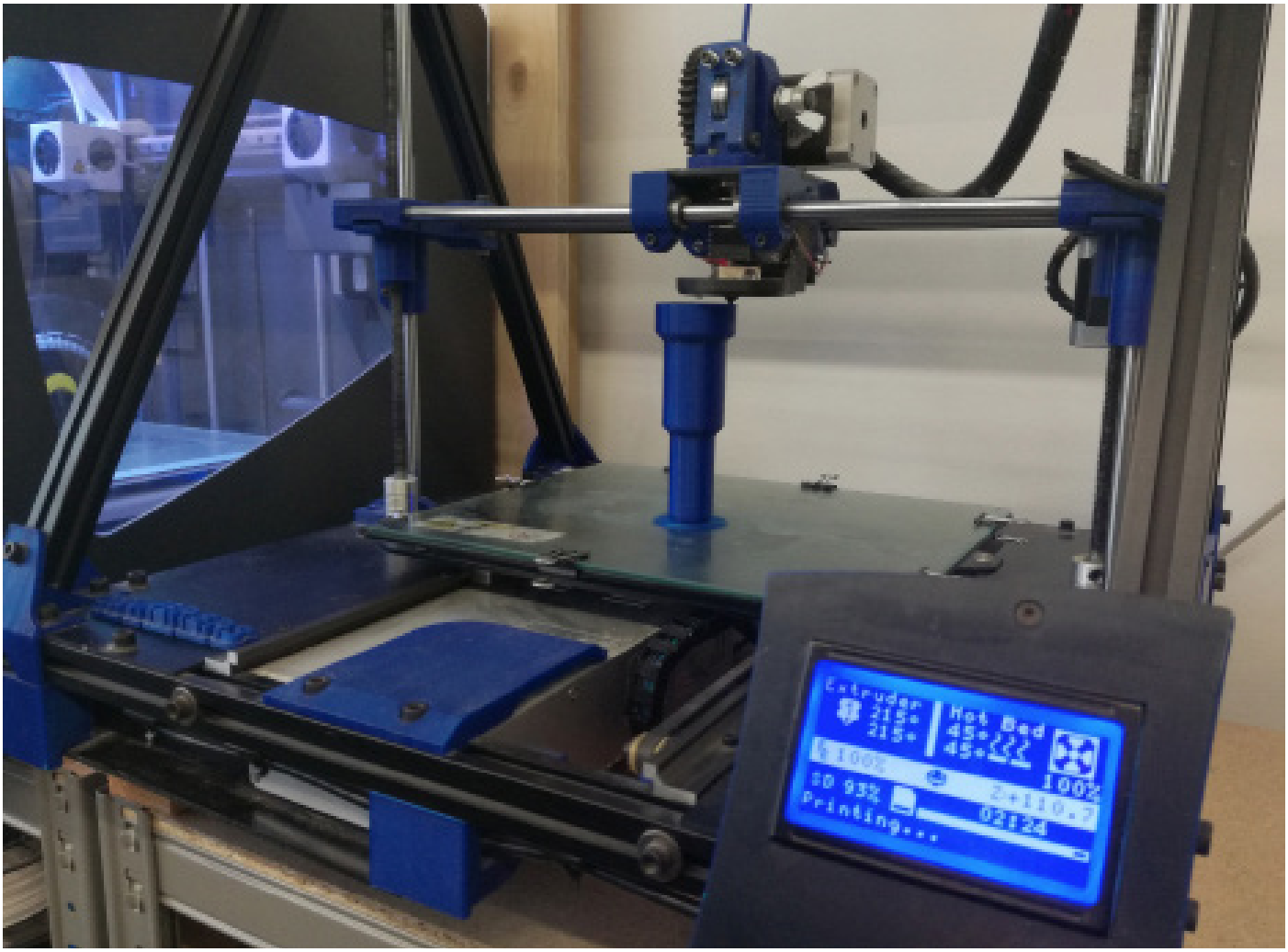
These case files can be printed using any 3D printer, we are using the Form Labs 2 to print the lenses and this will also work for the case also, however the Resin is expensive and we are using a clear resin to print the lenses. For this reason we choose to use an FDM (Fused Deposition Modeling' printer like the Rep Rap or Ultimaker for the case.

There are different types of Slicer software or CAM software for the Rep Rap and Ultimaker 2. We use Cura for use with the FDM machines. There is a lot of instructions online for Cura and it is suggested to read that as there are are a lot of options. Again this is just as much an art as it is a science.



TIP : You can print the casing in a vertical position with the widest part at the top, this seems counter intuitive but actually helps with delivering some of the interior parts. We find it best to use PLA filament because it is more ecologically friendly! Also using the Brim setting is sufficient to hold the object to the build plate, it also speeds up the process.

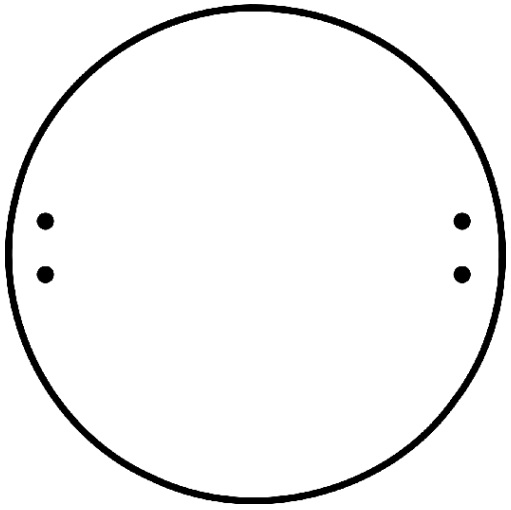
VIDEO : Printing Torch Holder



Step 9: Make PCB cutting files with FAB Modules

We want to cut co small round pieces of circuits called PCBs (Printed Circuit Boards). These will help position and hold the LEDs in place. The two PNG files below will be used to generate the machining strategies using Fab Modules. These can be downloaded from the file system.

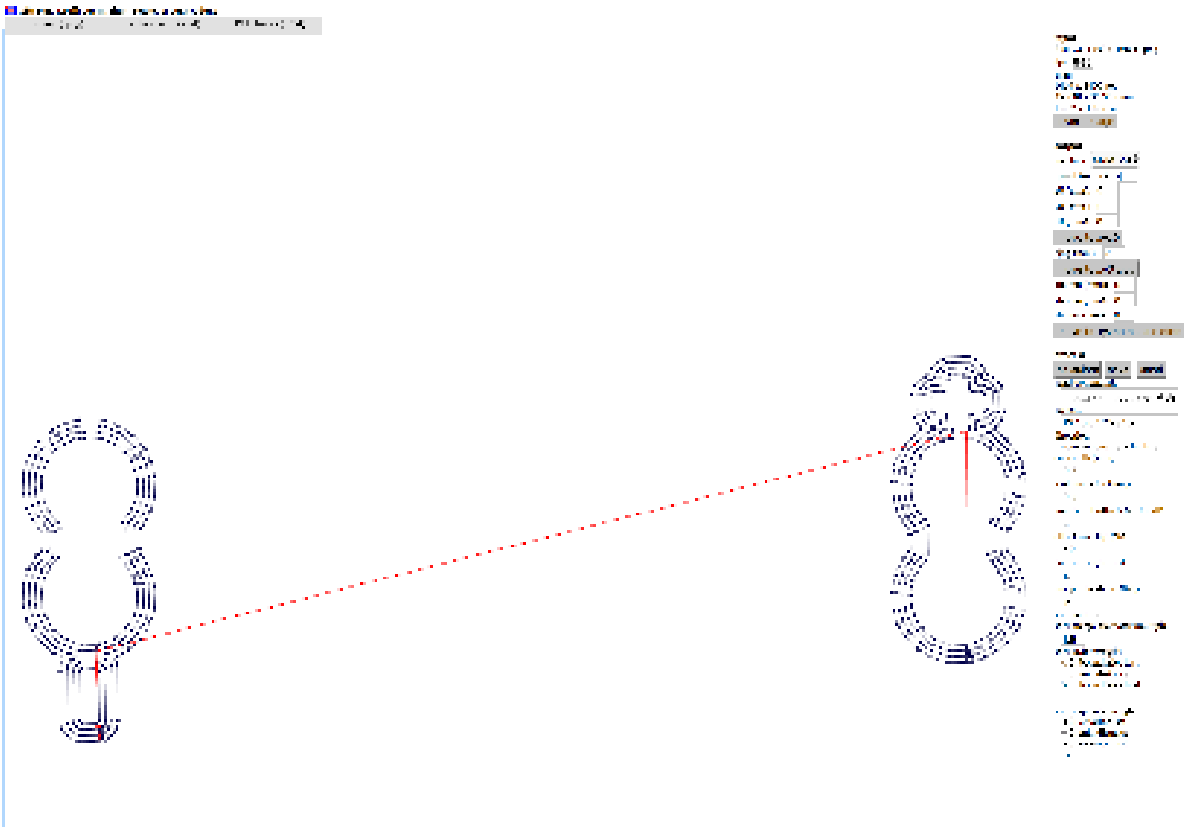
1 - PCB Profiles



2 - PCB Traces

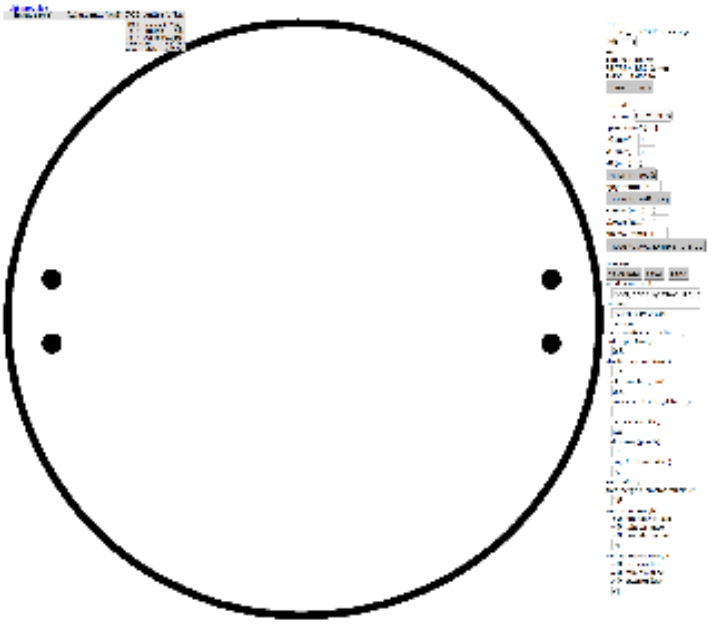
The PNG files have a page size that will allow the machine to accurately return to the same position between the two processes of first cutting the Traces and then cutting the Profiles and holes. Fab Modules is open Source CAM software designed for the Fab Academy. It allows users to generate machining strategies for lots of different processes and machines, it runs in the browser so there is no need to download it. We will be using the Roland MonoFab SRM - 20 milling machine.

You can load the files from your computer into the software and select the process in a guided steps. The image below shows the settings and tool paths of the Tracing file. We are using a tiny milling bit here and it will only need to remove 0.5 mm of material from the top of the copper PCB blank.

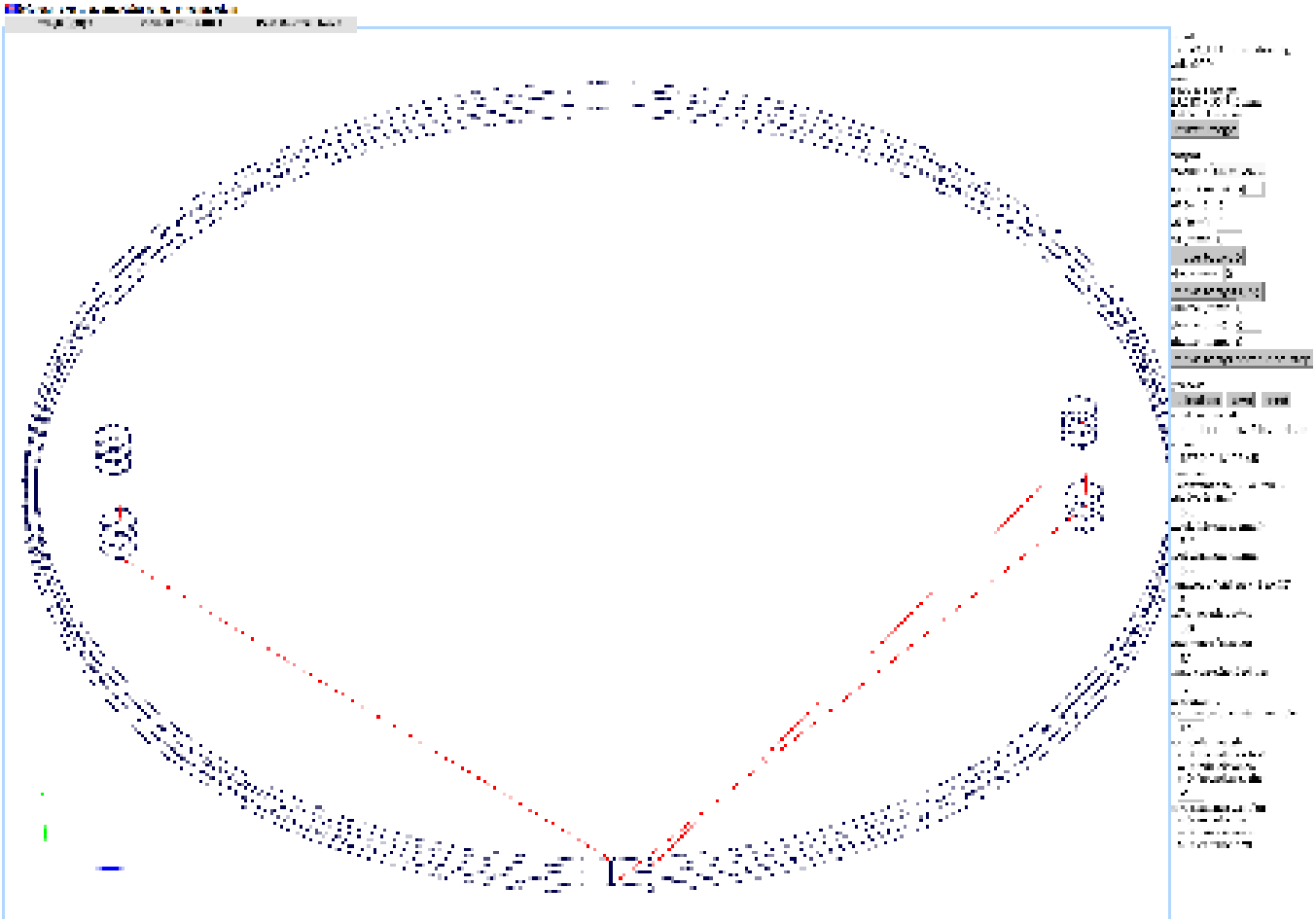


Once you have finished setting up the cutting strategy and are happy that the speeds and depths are correct you should save the file. This will download it to your computer as a .rml file.

The next file to be prepared are the Profile or Outlines of the PCBs. We will use a bigger milling bit and this time will cut all the way through the blank. Select the PCB outline option



The image below shows how that the tool paths have multiple levels. The settings show a thickness of 1.8 mm



Step 10: Mill PCBs usinig ROLAND MONOFAB

The Roland Monofab is a desktop milling machine that cuts material. It moves in much the same way as a 3D printer, but instead of adding material it subtracts it. The CAM software that controls the machine is called V panel, which will use to run the .rml files that we created in the previous step from Fab Modules.

First is we will need to secure the Blank PCB to the bed of the monofab with double sided tape. Then by moving the Milling bit at the bottom left corner of the blank we can Zero the X and Y axis using the User coordinate system.

TIP : *In the Z axis, bring the milling bit down to a few mm above the blank and then loosen the chuck to let the milling bit drop to the surface. Only then Zero the Z axis.*

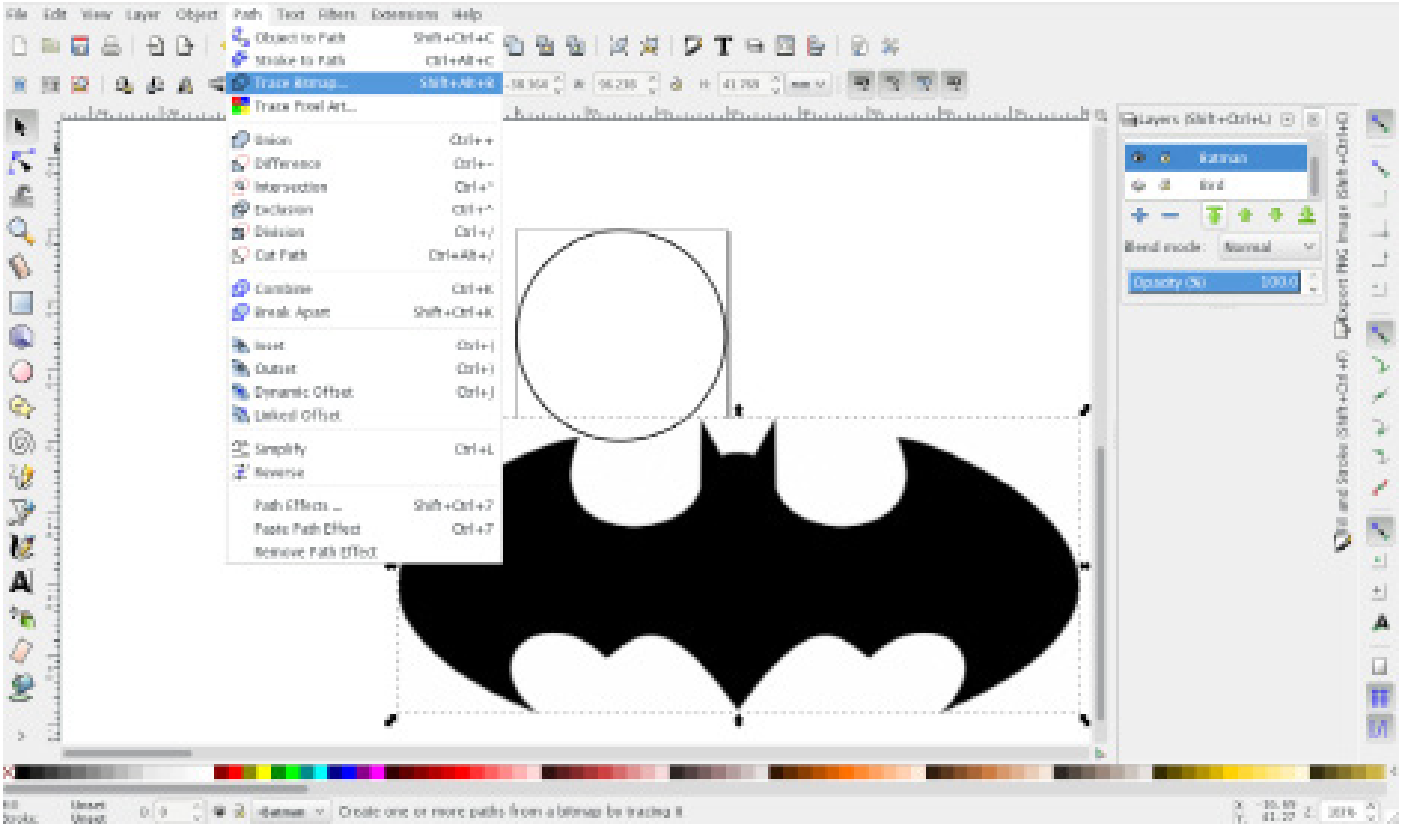
VIDEO : Milling machine cutting boards

Step 11: Design a stencil

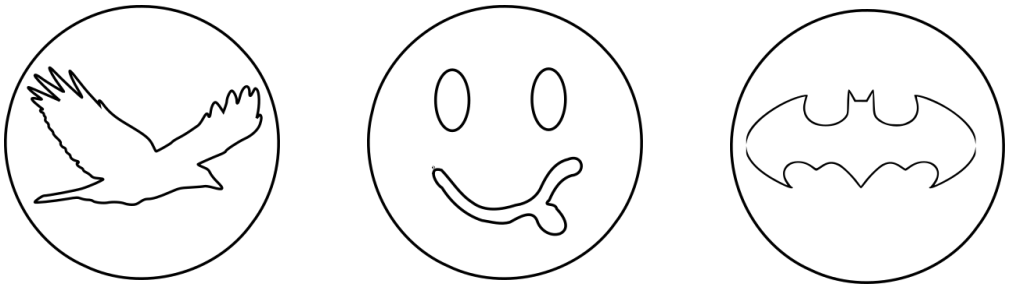
Inkscape is free open source software for any platform. It allows allows us to make digital drawings in 2D. It is a great tool for any designer to to make vector drawings. There is a lot of information on the web about how to use inkscape.

For this design process we will be making drawings that will be loaded into Fab Modules CAM software and will then run the Roland Vinyl Cutter.

TIP : *Images can be downloaded and traced into a vector image using the tool shown below:*



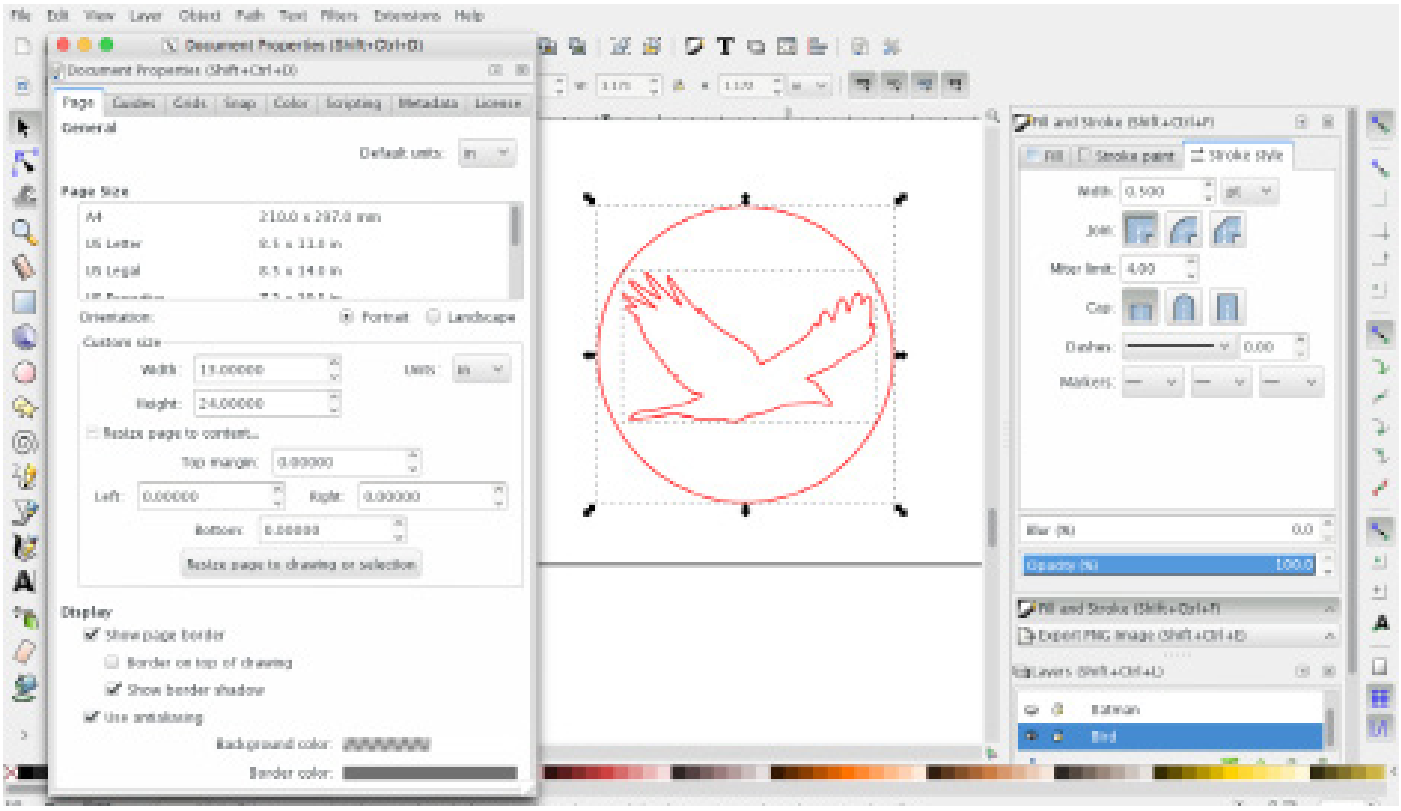
The images that we draw should be made within 30mm by 30mm circles. The lines that are made should be 0.5 pt and should be unbroken. (The batman image has broken lines).
The files can be saved in .svg format.



Step 12: CNC Vinyl cut a stencil

The Roland Vinyl cutter is a CNC machine for cutting signs, stickers, circuit boards and any 2D shapes. It uses a small knife to cut into rolls of material. We will use the drawings that we made with inkscape to load into Fab Modules. These will be the .svg files.

This documentation from the Fab Academy archive is helpful



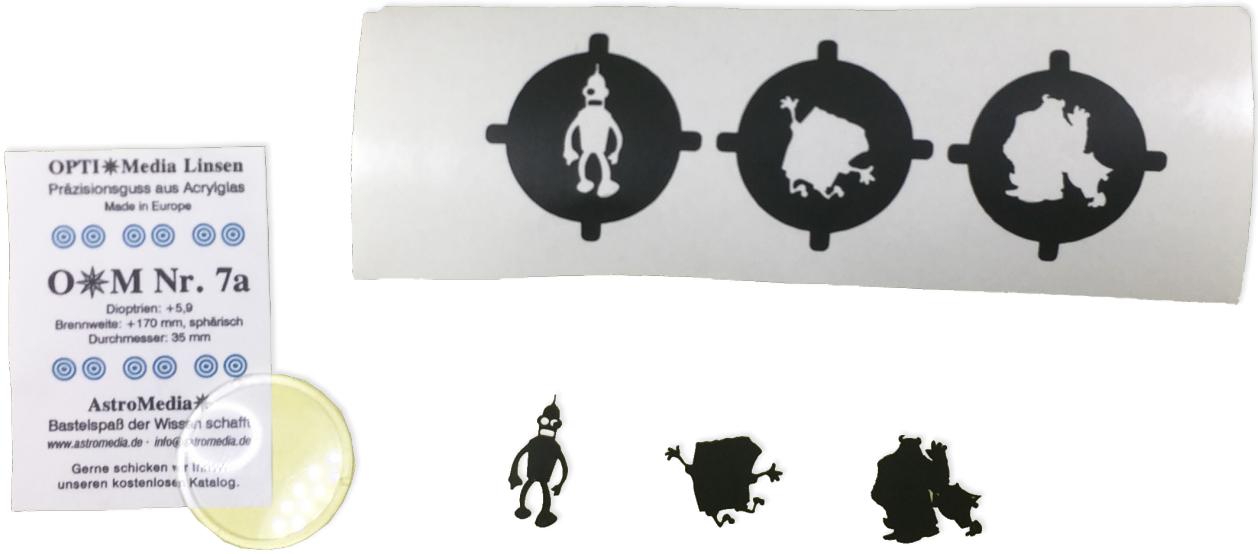
VIDEO : VIYNL Cutter making

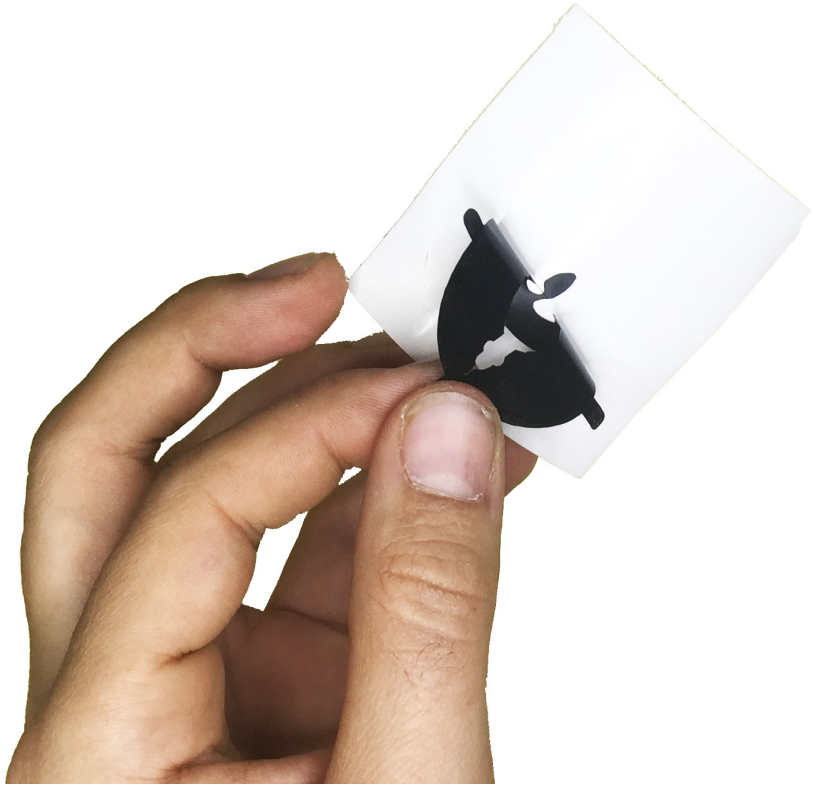
Once you have cut the Vinyl stencil you will need to remove the sticker from the rest of the vinyl roll. This process is called weeding and can best be achieved with a pair of tweezers.

Once the Sticker is complete it can be stuck directly to the back of the lens, or to a disk of transparent acrylic.

Optional: Vinyl cut as stencil

If you do not have a laser cutter, you can cut the stencils with the vinyl cutter and paste them directly to the flat part of the lens, as shown in the photographs.





Step 13: Solder an LED circuit

We will now need to place and Solder the white clear 3W LEDs (Light Emitting Diodes) to the PCB and connect the 9v battery to and switch to the circuit also. We have made the PCBs to help locate into the case and distribute heat from the power LED. The PCBs are made to help make the assembly and soldering process more stable and simple. The most important factor of this is to know that the LEDs have a polarity with a positive and negative side.

TIP : The + side of the the LED is the Positive side.

First, push the longer legs of the six LEDS through the locating holds of the first PCB. This will help keep them in place. Make sure that the Longer legs are rotated towards the centre.

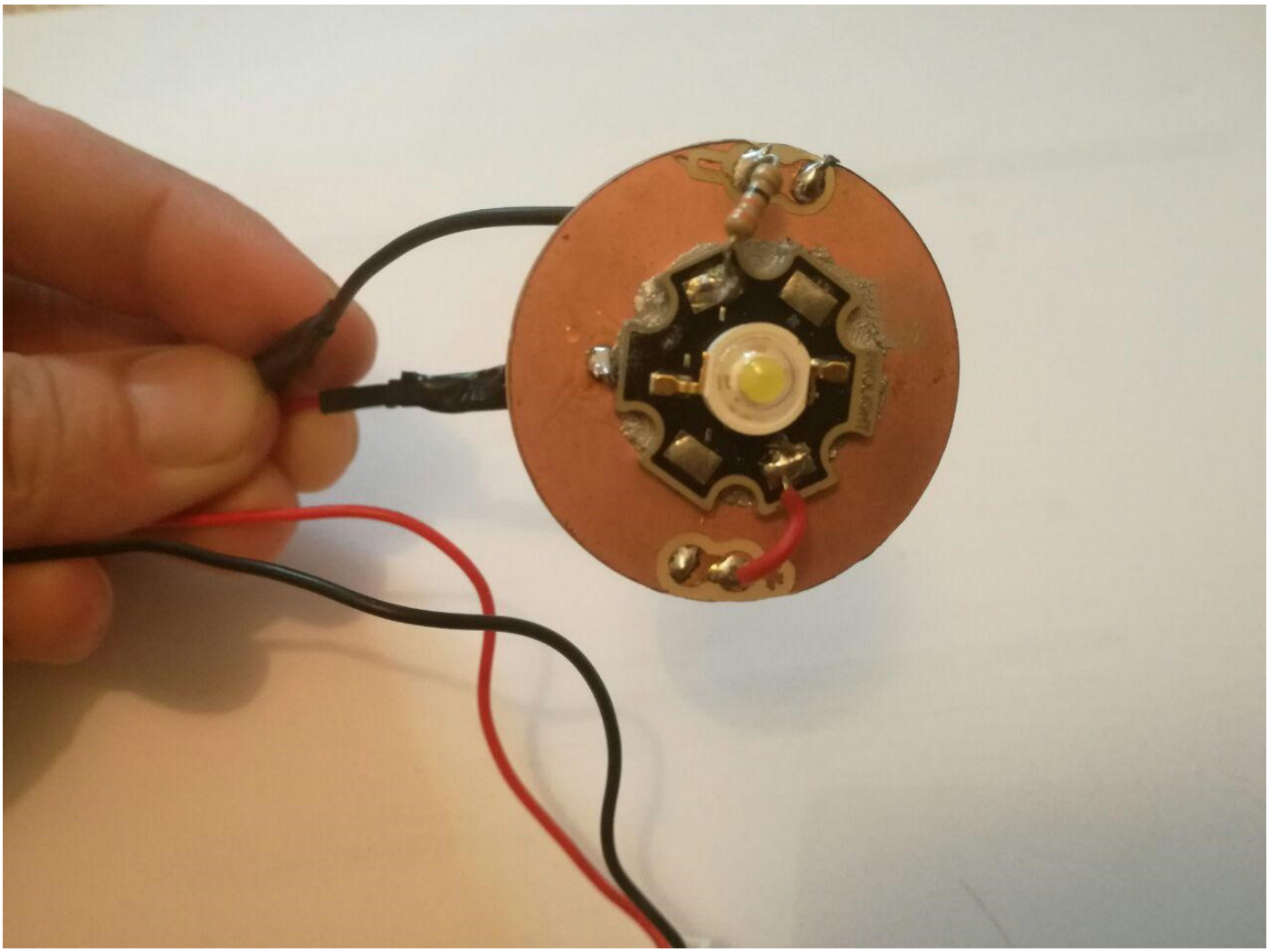
Next is to solder the Legs to to the PCB traces checking that you have created. To do this you will need to have a Soldering Iron, a roll of Solder and some flux to help you with the connections.

The Soldering operation will happen in 3 steps.
1 > The first objective is to cover the connection with Silicon Thermal paste
2 > Second is to solder the both Red and Black wires to the switch and to the battery socket and to the 150 ohm resistors.
3 > The final step then is to Solder the Black and Red wires to the circuit board with the Red positive placed in the center.

TIP : Make sure that the Red and Black wires that you use to connect the switch to the LED circuits are long enough to extend the length of the Torch case.

VIDEO : 1_Soldering the circuit

Once you have soldered the LED legs to the the circuit board you can remove some of the extra length of the legs to LED legs by cutting them off with some clippers.



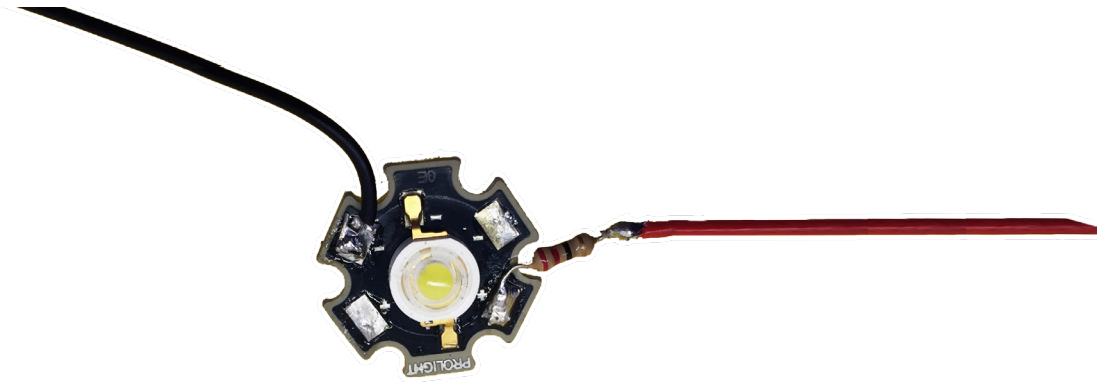
To Solder the switch it is more simple to solder both the wire and the battery cable to the pins at the same time. There are holes in the pins that you can push the wires through.

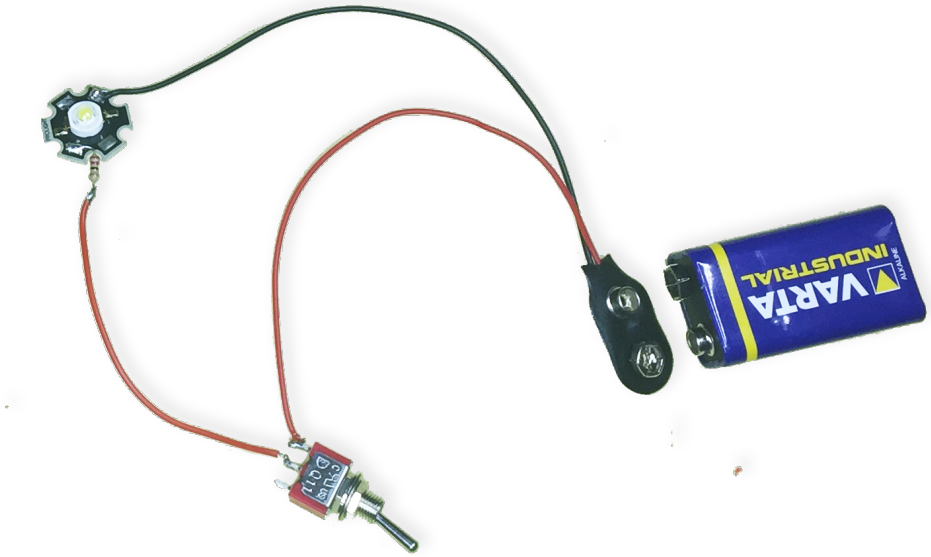
VIDEO : 2_Soldering the switch

VIDEO : 3_Connect the Battery

Optional: LED + resistor

If you do not have a precision milling machine CNC, you can always solder a resistance directly to the led, as shown in the picture.




VARTA
INDUSTRIAL

Step 14: Assemble the light torch

You will now have all the components that you need to be able to assemble the Torch. You will start by pushing the Switch all of the way through the casing housing so that it protrudes through the bottom hole.

TIP : Use some string to pull the switch and guide it through the casing and out of the hole.

VIDEO : 4_Assembly the Torch
VIDEO : 5_Lense Insert
VIDEO : 6_Connecting Torch Battery

TORCH PROJECTOR

ICFO

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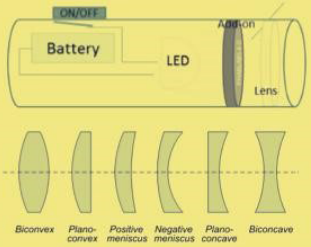
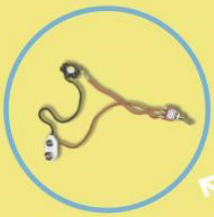
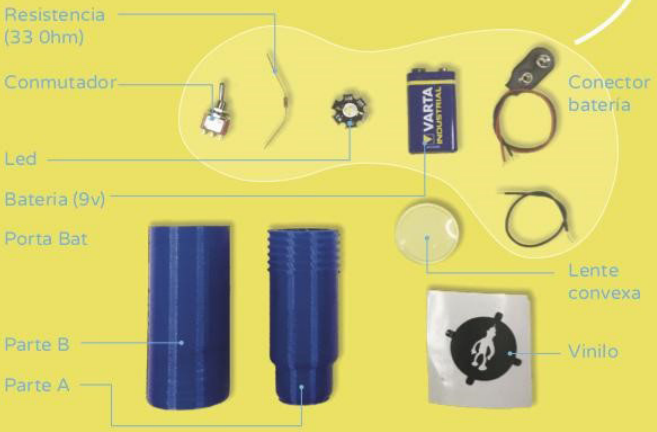
01 KIT DE PARTES

"Construyendo una linterna que permita proyectar plantillas personalizadas."

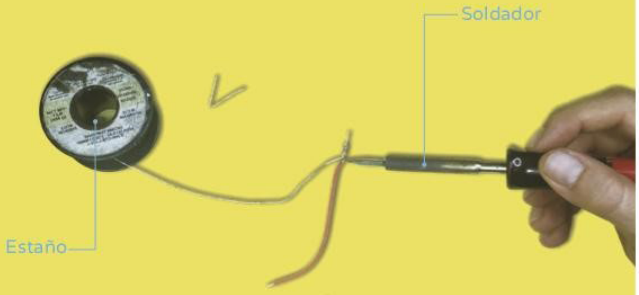




Circuito elétrico



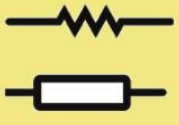
02 SOLDAR LA RESISTENCIA



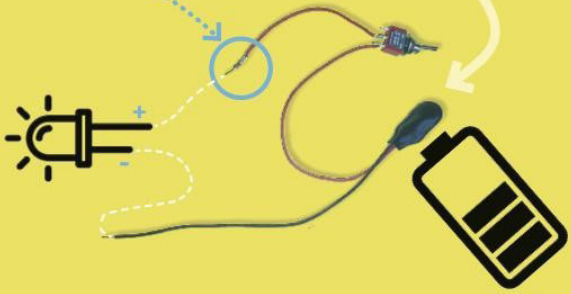
La resistencia es un dispositivo eléctrico que tiene la particularidad de oponerse al flujo de la corriente.

LEY DE OHM
V = I * R

SIMBOLOGÍA



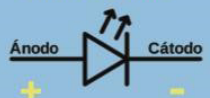
03 CONECTAR EL CONMUTADOR

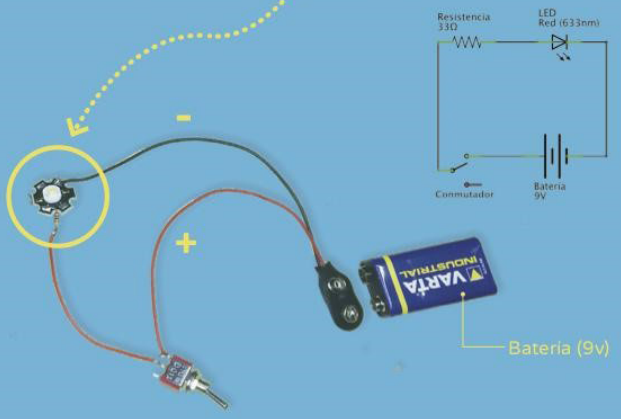


04 SOLDAR LED

Un led es diodo cuya función principal es convertir la energía eléctrica en la emisión de fotones (luz).

SIMBOLOGÍA



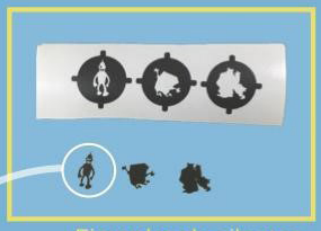


05 MONTAJE PARTE A - CIRCUITO

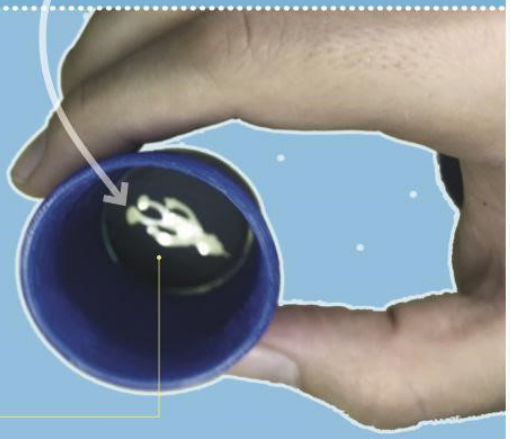
Introduce el conmutador por el hueco inferior de la parte A

Insertar bateria OJO! nunca tener el Led encendido

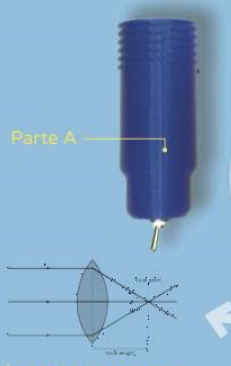
06 PEGAR VINILO A LA LENTE



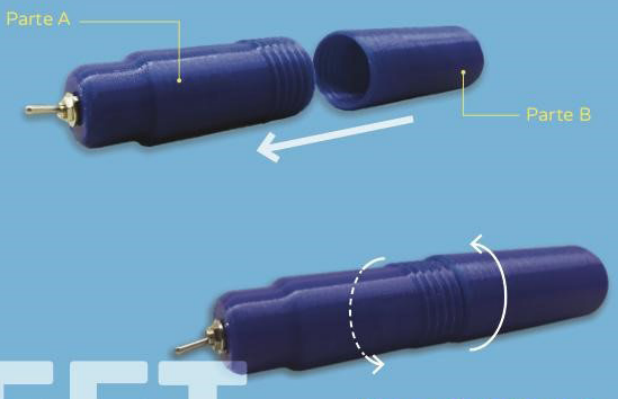
Ejemplos de siluetas



07 MONTAJE VINILO - PARTE B



Colocar lente en la base superior de la Parte B



FET

PHABLABS 4.0

PHABLABS 4.0 is a European project where **two major trends** are combined into one powerful and ambitious innovation pathway for digitization of European industry:
On the one hand the growing awareness of **photonics** as an important innovation driver and a **key enabling technology** towards a better society, and on the other hand the **exploding network of vibrant Fab Labs** where next-generation **practical skills-based learning** using KETs is core but where photonics is currently lacking.

www.PHABLABS.eu

This workshop was set up by the *Institute of Photonics Sciences, ICFO* in close collaboration with *Fablab Barcelona and Tinkerers Lab.*

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ICFO The Institute of Photonic Sciences

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NUI Galway OÉ Gaillimh

JOANNEUM RESEARCH

CNR IFN Istituto di Fotonica e Nanotecnologie

TU Delft Delft University of Technology

UNIVERSITÉ JEAN MONNET SAINT-ÉTIENNE

Eyest vzw

ECOP European Centres for Outreach in Photonics