
Mathboard

Release 1.0

Magne Lauritzen

May 06, 2024

CONTENTS

1	Contents	3
1.1	Mathboard user manual	3
1.2	Mathboard V1 assembly manual	4

The Mathboard is a small keyboard that gives you access to a wide range of mathematical symbols and the entire lowercase and uppercase greek alphabet. It works alongside your normal keyboard, and requires no software to use (except on Windows).

This documentation gathers all information on the Mathboard:

- Usage
- Assembly
- Troubleshooting

The Mathboard is fully open source and can be built by nearly anyone with a few simple tools. If you wish to build your own, this documentation will guide you step by step through the process.

CONTENTS

1.1 Mathboard user manual

To set up your Mathboard for the first time, see *First setup of the Mathboard*.

1.1.1 First setup of the Mathboard

The Mathboard *almost* works straight out of the box, but there are some initial setup tasks that must be performed. These tasks will depend on the computer that you intend to use the Mathboard with.

Software

If you intend to use the Mathboard on an Apple Mac or any Linux-based operating system, you can skip to the Firmware section. If you intend to use the Mathboard on a Windows computer, you must first install the lightweight application [WinCompose](#) which provides support for Unicode input.

Firmware

The firmware of the Mathboard must match the keyboard layout of the computer on which you intend to use it with. This is a consequence of both how operating systems interpret keycodes from keyboards, and the inability of the Mathboard to automatically deduce the keyboard layout of the computer it is plugged in to.

You must therefore upload, or “flash”, a version of the firmware that matches your keyboard layout. Start by figuring out your keyboard layout (google can help you here). Then go to the [latest release](#) and download the firmware file for your keyboard layout. Then, plug in the Mathboard and press the reset button (found on the bottom) for at least half a second. When you release the reset button, a folder will open on your computer. Place the firmware file in this folder to flash it to the Mathboard. The folder will automatically close when finished, and the Mathboard will reboot. Done!

Warning: Since the Mathboard is not fully released yet you must build your own firmware if you use a keyboard layout other than US ANSI.

Setting the OS switch

Each operating system [OS] interprets Unicode input differently. The Mathboard must therefore be configured to output Unicode that the OS can understand. Using the illustration on the bottom of the Mathboard, place the OS switch on the back of the Mathboard to the OS your computer is running.

1.1.2 Getting started

Make sure you have already followed the instructions in *First setup of the Mathboard*.

Accessing the Mathboard symbols

The Mathboard manages to pack a lot of symbols onto a small keyboard by placing more than one symbol on each key. When you click a key, it will output one of its six symbols depending on the state of the modifier keys.

There are three modifier keys: Blue, Green and Purple. The Blue modifier key accesses the symbols on the right side. The Green modifier key accesses the bottom symbols on the front face, and the Purple modifier key accesses the top symbols. You can combine the Blue and Green/Purple modifier keys to access any symbol.

When no modifier keys are pressed, clicking a key outputs the lower left symbol on the top face. This means that if you simply click the top left key, you will get the symbol (lowercase Alpha).

Multitap symbols

Certain symbols are marked by a small orange dot. Double-tapping such a symbol will output a different, but related, symbol than what's printed on the keycap. For example, double tapping produces . Double tapping produces .

Certain symbols can be tapped more than twice. For example, double- and triple-tapping gives you and .

Switching between modes

The Mathboard can switch between three modes: Unicode, LaTeX, and Microsoft Office Equations Editor. The current mode is indicated by the LED with the following color codes:

- Blue: Unicode
- Yellow: LaTeX
- Purple: Microsoft Office Equations Editor

Many symbols will be output differently depending on which mode is selected.

1.2 Mathboard V1 assembly manual

This part of the documentation is intended for those who wish to build their own Mathboard V1. If you are instead looking for documentation on how to use the Mathboard, see *Mathboard user manual*.

Assembling your own Mathboard from scratch typically takes one hour once you have all the parts ready. Once you're finished, head over to *First setup of the Mathboard* to set it up for use.

1.2.1 Components and tools

The Mathboard is a very simple device that should be possible to build by nearly anyone. The following two lists tell you everything you need to assemble your own. The following sections go into further detail on certain parts.

Components :

- 1x Mathboard PCB
- 16x [Gateron KS-33 Low Profile v2 switches](#)
- 1x [0xCB Helios RP2040 microcontroller](#)
- 1x 3D-printed Mathboard case (bottom, lid, and LED diffuser)
- 16x 3D-printed keycap risers
- 12x blank white 1u OEM R2 keycaps
- 2x 1u keycaps of your choice
- 2x 1.5u keycaps of your choice
- 3x self-tapping M2.2 x 6mm screws
- 4x rubber feet. Maximum footprint: 1cm x 1cm.
- 1x USB-C cable

Tools and supplies :

- A UV printer. This may be hard to find, inquire with makerspaces or fablabs near you.
- A 3D printer for printing the case, LED diffuser, keycap spacers, and UV printing fixtures.
- White PLA filament for the LED diffuser.
- Any color PLA filament, for the case, spacers, and UV printing fixtures
- A screwdriver, to insert the screws that hold the case together
- A soldering iron (plus solder) to solder the keyboard switches, the microcontroller, and the LED
- A wire clipper, to cut the microcontroller pins short after soldering
- Cyanoacrylate glue (AKA super glue), for gluing the LED diffuser to the case lid.

Mathboard V1 PCB

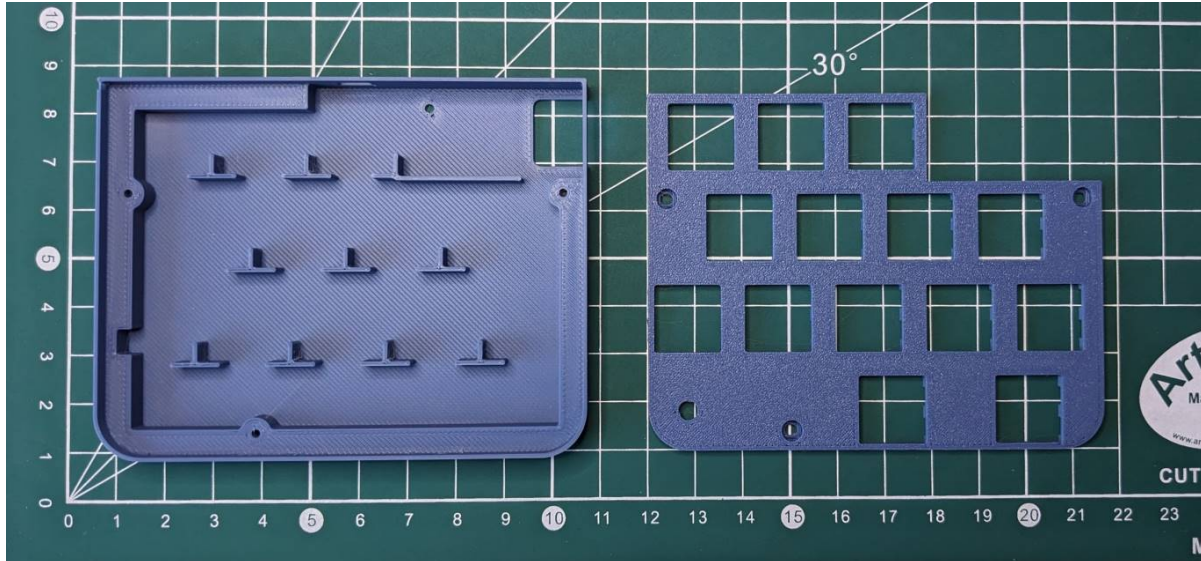
The mathboard V1 PCB can be manufactured by any electronics prototyping company. I have previously used JLCPCB, and a correctly formatted Bill of Materials [BOM] file for use with them is provided in the Mathboard repository.

You can order the PCB pre-assembled with most of the components already soldered on, but some must still be soldered by hand. These include the 16 switches, the microcontroller, and the status LED. These components are all through-hole mounted and are simple to solder.

TODO: Add an image of the PCB

3D printed components

The Mathboard is designed with 3D printing in mind, and it should be possible to produce its parts with any filament extrusion 3D printer. It may also be possible to use a resin printer, but I have not tried that. I recommend printing the Mathboard in PLA, but you can probably use other materials as well.

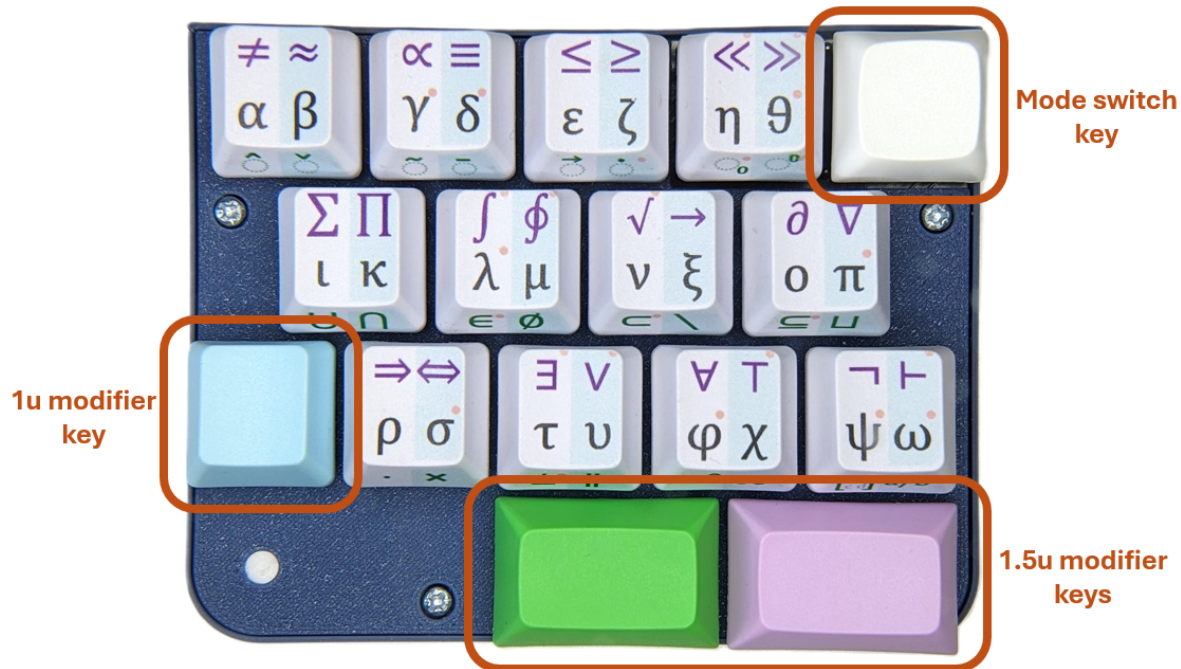


You don't need any special slicer or printer settings for the Mathboard case: All three parts, meaning the bottom, lid, and diffuser, should print fine with default settings.

Keycaps and UV printing

Blank keycaps can be purchased from many sources. For the symbol keys you must use 1u OEM R2 keycaps, such as [these](#). The reason for this is that the decals are made with these profiles in mind. For the other keys you are free to choose which keycaps you prefer. You will need :

- A 1u keycap for the mode switch key
- A 1u keycap for the left modifier key
- Two 1.5u keycaps for the bottom modifier keys



The most challenging aspect of building your own Mathboard is getting the symbols onto the 12 symbol keys. This is done by UV printing, which prints the symbols onto the keys with special UV-curing ink. A UV printer is expensive and requires regular maintenance, so it is not a common device. You may be able to find one if you inquire with local makerspaces, fab-labs, or printing services.

Note: A collaboration with [3Dkeycap](#) is underway, which will allow you to purchase ready-to-use Mathboard keycaps from their webstore. As of April 2024 this collaboration is still in the early stages. Inquire in the [Mathboard Discord](#) for more information.

Self-tapping screws

Any type of self-tapping screws may be used. Self-tapping screws are also known as thread-forming or self-drilling screws. Three are used in the Mathboard to assemble the case. Their dimensions must conform to the following requirements:

- Length (measured from bottom of head) : 3mm to 6.8mm
- Thread diameter : 2mm to 2.5mm
- Head diameter : 2mm to 4mm

It is recommended to use M2.2 x 6.5mm screws if you can find them, for example [these](#).

1.2.2 3D printing the Mathboard parts

Note:

Prerequisites:

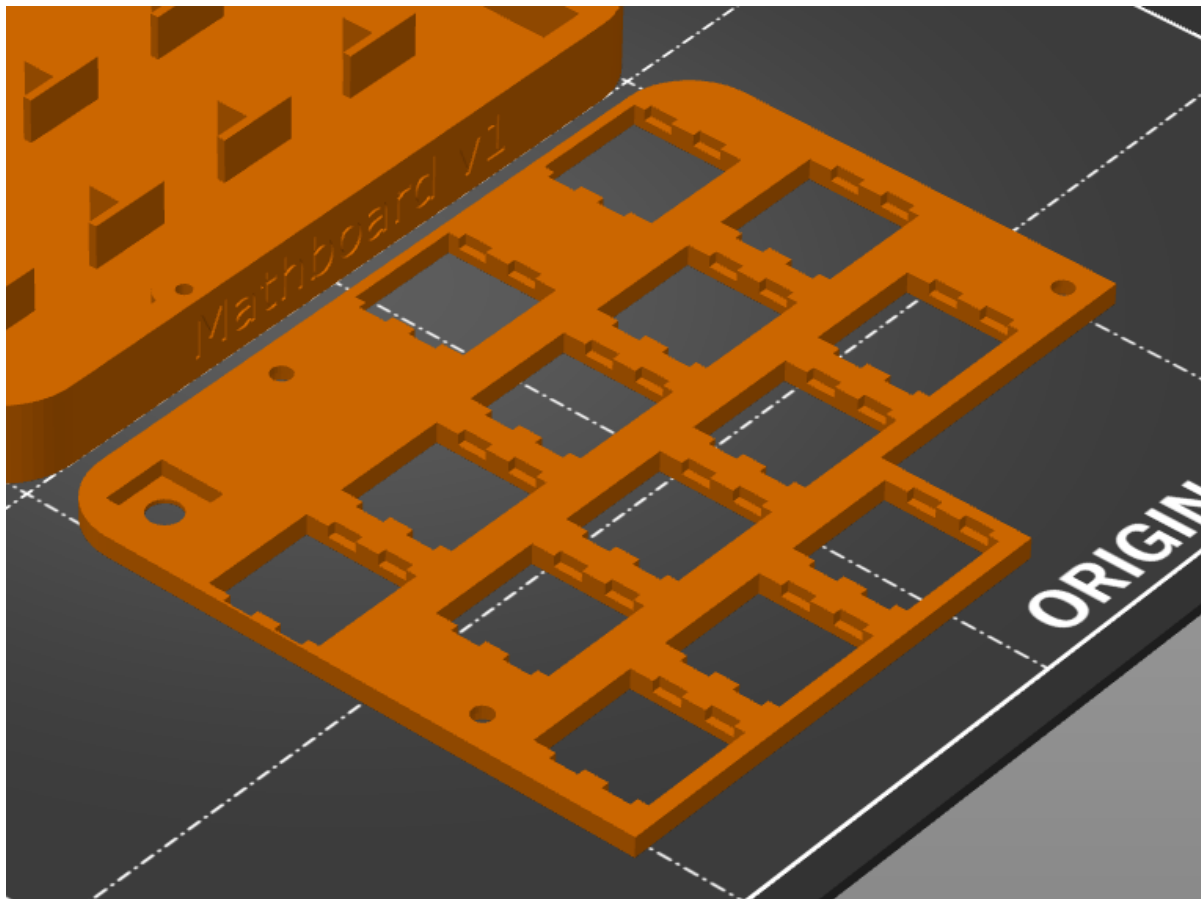
- A 3D printer with at least 8cm x 10cm build surface
 - PLA filament of any color for the case
 - White PLA filament for the LED diffuser
-

Printing the case and diffuser

Open your slicer software and import the following two Mathboard case files:

- /hardware/case/Bottom.stl
- /hardware/case/Lid.stl

They can be printed at the same time using the same settings. They are simple parts, and should be printable with the default settings of your slicer. **Ensure that the lid is printed upside down**, as shown here:



Once the bottom and the lid have been printed, move on to the diffuser. Import the following file in your slicer software:

- /hardware/case/Diffuser.stl

This part must be printed with white filament to allow the status LED to shine through. Again, this part should be printable with default slicer settings.

Printing the keycap risers

The keycap risers exist to make the OEM R2 keycaps compatible with the low profile Gateron switches. They raise the keycaps up by 1mm so that they do not crash into the top of the Mathboard before the switch has been fully pressed.

You will need 16 of these keycap risers, one for each switch on the mathboard. Import the following file in your slicer software:

- /hardware/case/Keycap risers.stl

The keycap risers are very small components with tight tolerances, and may require some tuning to print correctly. I have personally had success with the following settings:

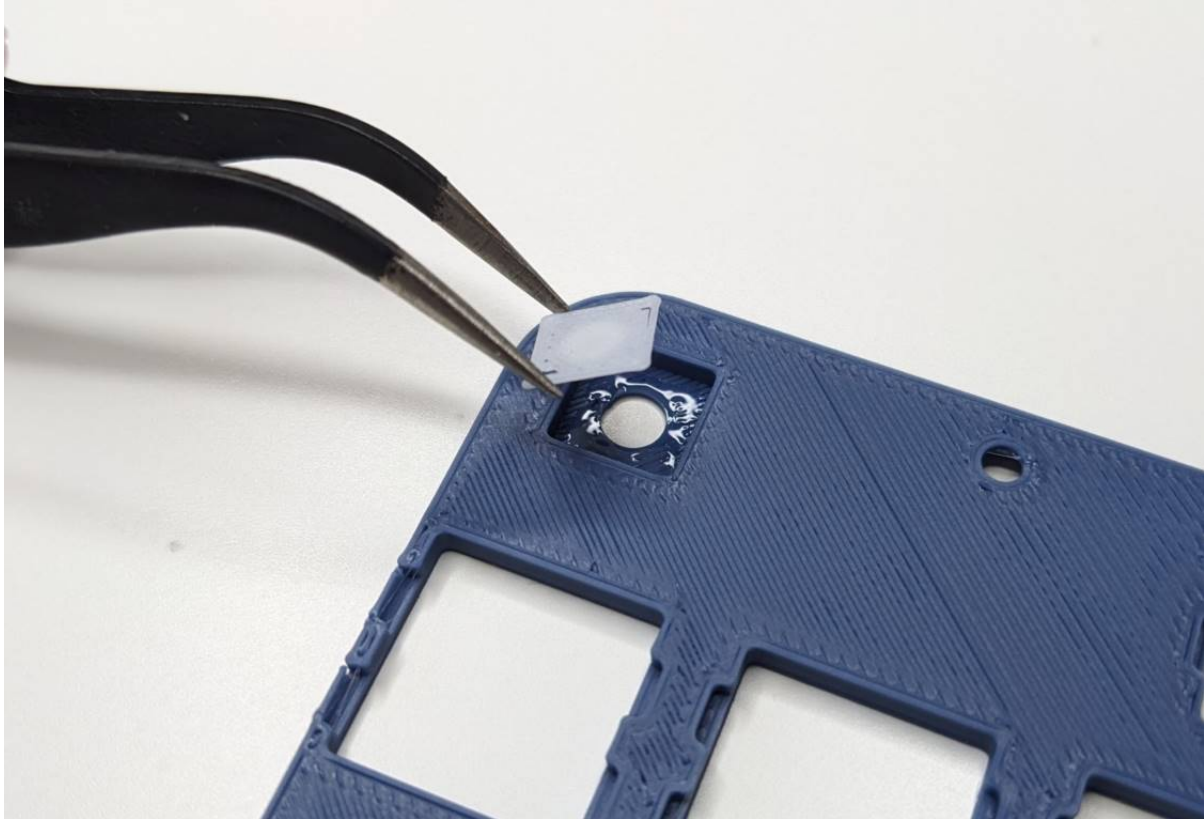
- Layer height : 0.2mm
- Skirt : Yes
- Speed : 20% of normal

1.2.3 Assembling the lid

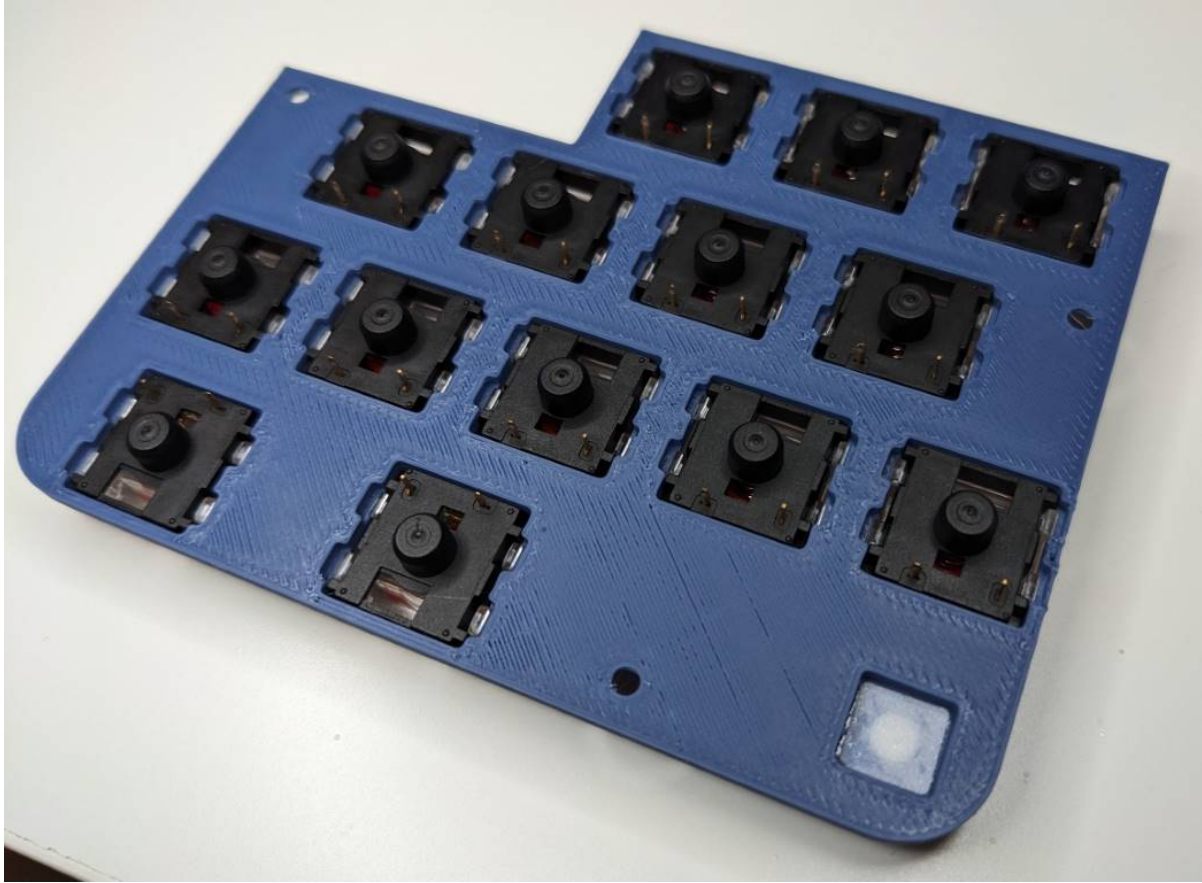
Note:**Prerequisites:**

- 1x Mathboard lid
 - 1x Diffuser
 - 14x [Gateron KS-33 Low Profile v2 switches](#)
 - Cyanoacrylate glue
-

Begin by gluing the diffuser into the lid. Add a small amount of glue to the flat part of the recession in the lid where the diffuser will sit. Insert the diffuser and apply pressure to ensure that it is flush with the lid surface. The glue should dry within 5 minutes.



Once the glue is dry and the diffuser won't fall out, insert the Gateron switches into the lid. Ensure that they are inserted in the correct orientation. Note that the two bottom switches must be oriented with 180 degrees rotation.



1.2.4 Soldering the PCB

Note:

Prerequisites:

- 1x Mathboard PCB
- 1x 0xCB Helios RP2040 microcontroller
- 2x Gateron KS-33 Low Profile v2 switches
- 1x *Assembled lid*.
- A wire clipper

The Mathboard has been designed to be easy to make. Thus, the PCB only uses through-hole components for the parts that must be soldered by hand. Through-hole components are easy to solder even with low-quality soldering irons and no previous experience.

Switches

Place the *Assembled lid* on a flat surface with the switches pointing down. Place the PCB on top of the lid, with the switch pins going through the PCB. Solder all the switch pins to the PCB.

Tip: The Mathboard PCB is thin, and has a tendency to flex. It is a good idea to apply bit of pressure to the PCB when soldering the switch pins so that the PCB is flush with the lid.

TODO: Insert image of soldering the switches

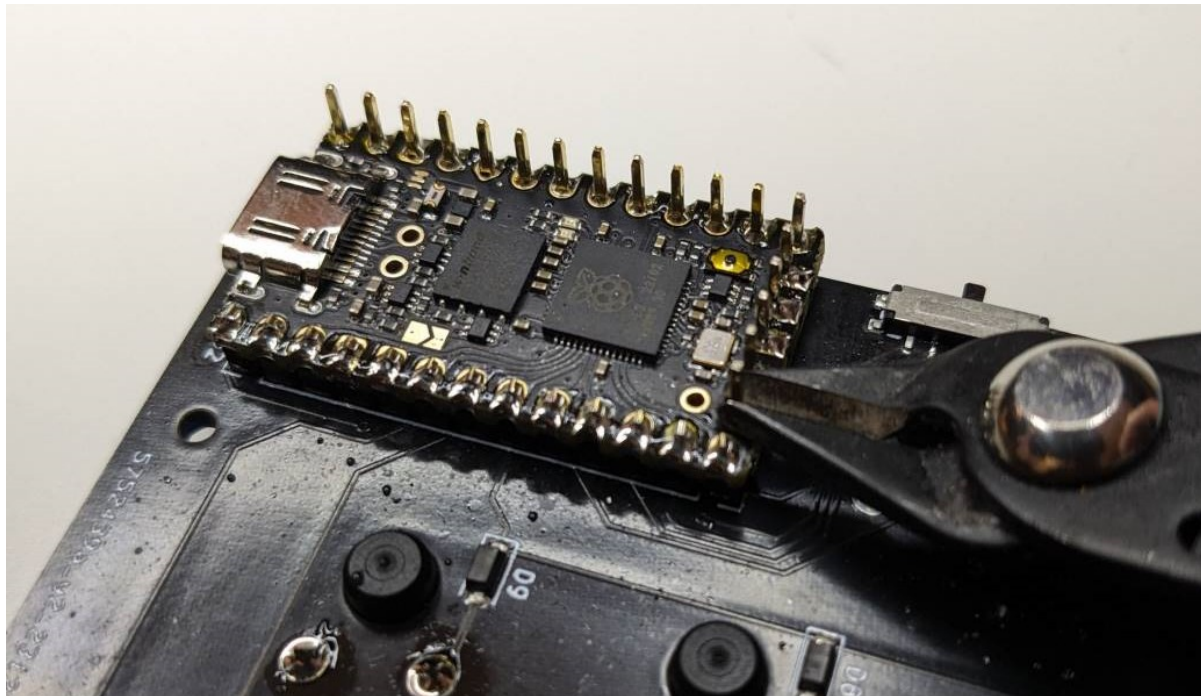
Insert two Gateron KS-33 Low Profile v2 switches in the two slots surrounded by the microcontroller pin headers. Solder them to the PCB.

Microcontroller

Important: Do not solder the microcontroller before you solder the two top right switches, as their solder pads are covered by the microcontroller.

Place the 0xCB Helios RP2040 microcontroller on the pin headers. Be careful to not place it upside down. The side with all the components on it must be visible. See the photo below for reference.

Solder the microcontroller to the pin headers. Once finished, use the wire clipper to cut the pin headers short.



1.2.5 Integration and keycaps

Note:**Prerequisites:**

- 1x Mathboard bottom
 - 1x *Fully assembled lid with PCB*.
 - 3x self-tapping M2.2 x 6mm screws
 - 4x rubber feet
 - 16x keycaps
 - 16x *keycap risers* if using OEM R2 keycaps
-

Insert the *Fully assembled lid with PCB* onto the bottom at an angle, so that the small OS switch on the back of the PCB can enter its cutout in the bottom. Then, lower the lid down until it sits flush with the bottom. Screw the lid onto the bottom using the self-tapping M2.2 x 6mm screws. Flip the Mathboard over and attach the rubber feet.





Keycaps

If you are using OEM R2 keycaps, first place one *keycap riser* into each switch. The risers have tight tolerances, and they might not fit if your printer did not print them correctly. Place the keycaps on the switches and press down well to insert them fully into the switches.

