Mathkeeb™ Assembly Guide

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Welcome!

Thank you for purchasing an Apogee Industries Mathkeeb™! This guide will outline the general assembly of your Mathkeeb kit, as well as provide some helpful tips to ensure successful assembly.

Getting Started

In order to assemble your keyboard, you will need the following resources:

1. An Apogee Industries Mathkeeb™ kit
2. A soldering iron and solder
3. A phillips head screwdriver
4. About an hour of time

Bill of Materials

Before building your kit, please ensure you have received the proper amount of parts as listed below. If you are missing a component, please recount and send us an email at support@apgind.com

1. (1x) Mathkeeb case (upper half)
2. (1x) Mathkeeb case (bottom cover)
3. (1x) Teensy microcontroller
4. (1x) Mathkeeb PCB
5. (55x) mx-mount switches
6. (55x) Mathkeeb keycaps (54 1u and 1 2u)
7. (55x) 1N4148 DO35 Diodes
8. (1x) 2u stabilizer
9. (3x) m3 6mm screws
10. (4x) Rubber feet
11. (24x) MOLEX header pins

Safety Notice

Assembly of the Mathkeeb involves soldering electronic components. There are a few hazards to be mindful of during the assembly process that could affect you or your Mathkeeb. Please do not let these hazards discourage you from assembling the keyboard! It is a fun project and very easy for beginners. You do not need much previous soldering experience to assemble the keyboard overall, however if you are new to soldering please watch a tutorial before proceeding to ensure the best outcome.

Things to keep in mind:

Electro-static safety: Electrostatic Discharge (ESD) is hazardous to electronics. This should be kept in mind while handling the PCB or the Teensy microcontroller. We recommend assembling your keyboard on a non-conductive surface, and in a room with a non-conductive floor as well if possible (ie. tile rather than carpet). Other ways to reduce the risk of ESD include: wearing rubber soled shoes, wearing an anti-static wrist strap, and properly grounding yourself occasionally.

Metal fume fever: Soldering, if not done properly, can be hazardous to the body. Please perform all soldering in a well ventilated area, with a fume extractor if possible. Inhalation of fumes from any type of solder can be harmful, especially after long term exposure. Please be mindful of fumes when soldering!

Hot irons: Soldering is accomplished by heating two substrates with a heated tool (soldering iron) and connecting them with a molten filler material (solder). By their operating nature, soldering equipment becomes very hot! Please keep this in mind while assembling the keyboard. The keyboard parts can be easily damaged from contact with the iron (such as the case or keys). Please do not place your iron on flammable or easily meltable materials, or on living things.

Sharp parts: Each Kailh switch (and most other switches) is equipped with two gold-plated prongs that index with the soldiering holes on the PCB. These metal prongs are fragile and can be rather sharp. Please handle your switches with care while installing them.

Lead Poisoning: Please note that our PCBs have an HASL surface finish which contains lead. While this won't pose a danger to anyone operating an assembled Mathkeeb, it is important to keep in mind during assembly. Please practice safe lead handling techniques when interacting with the PCB or leaded solder, and avoid eating, touching your face, or any activity which may lead to accidental lead exposure.

Mathkeeb Assembly

Ready to begin? This section will cover the actual assembly of the keyboard. Please ensure you have verified your supply of parts, and that none are missing. If you *are* missing any parts, please contact us at sales@apgind.com and be sure to include 'Mathkeeb' in the subject line.

NOTE: Please read the instructions carefully and ensure you are following them in the correct order. Some parts cannot be installed after others!

Prepping the PCB

For this section you will need:

1. The PCB
2. Diodes
3. MOLEX header pins
4. Teensy microcontroller

The printed circuit board is what will connect every electronic component of the Mathkeeb, so it is important to take care while working with it.

Please place your PCB on your working surface and check it for any obvious damage.

Please set aside the molex pins and the microcontroller for now, and grab your diodes. *(If you are wondering at this point why we are using through-hole mount diodes, it is because they are cheaper, easier to work with, and I think they look cooler)* We will be using 55 diodes, so ensure you have the correct amount.

The diodes will need to go through the holes on the PCB on either side of the white rectangles labeled with a letter 'D' followed by a number. Please note the small black line on one side of the cylindrical section of the diode. This line will need to be on the same side as the thick white line in the white rectangle. Please refer to **Figure 1.1** to see an example of correct (and incorrect) diode placement.

It is recommended to install the diodes one row at a time. To place the diodes in the through holes, you will have to bend the metal pins into a U shape. Once the diodes are in the holes, it is recommended to bend the pins away from each other in order to keep them from falling out of place. See **Figure 1.2**

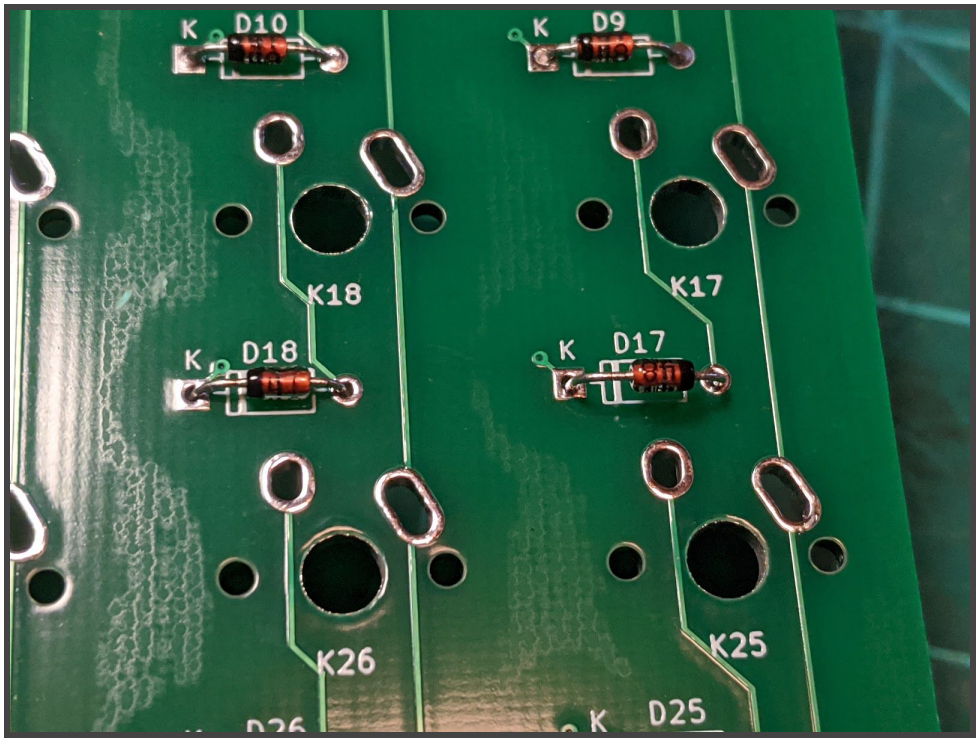

Figure 1.1 - *correct (left) and incorrect (right) diode directions. Note that the diode on D17 is installed backwards.*

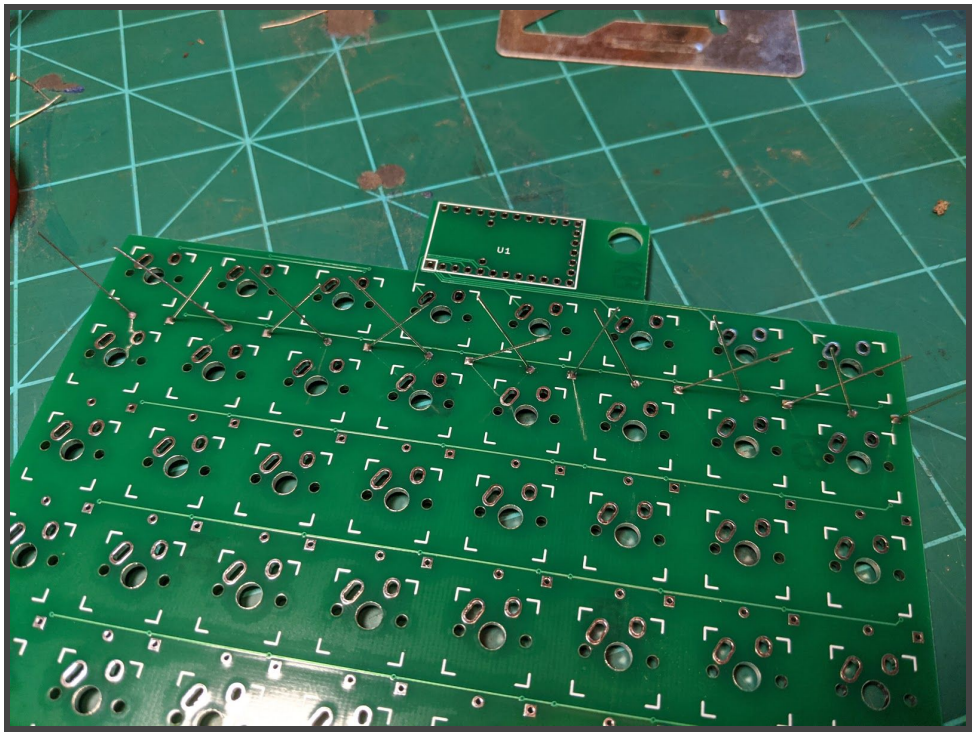

Figure 1.2 - *diode pins bent to hold them in place (top row)*

Once the diodes are securely in place, and you have assured they are oriented correctly, you may solder them in place. Once soldered on, you can clip all of the pins (shown in **Figure 1.2**) all the way down to the solder. This excess material is not needed and can be discarded. Repeat this procedure for all rows.

NOTE: There are some diodes that are oriented in different ways! Please pay attention to the diode labels on the PCB to ensure correct installation! **All** diodes must be installed correctly for the keyboard to properly register key presses!

Next we will bring our attention to the rectangular portion that extends from the top of the PCB. This is where we will mount the microcontroller. For this part we will need the molex pins, and the Teensy microcontroller. The molex pins will be soldered to the PCB, with the microcontroller soldered on top of them.

NOTE: Some versions of the Mathkeeb PCB were labeled incorrectly during manufacturing. Please pay close attention to ensure you are installing the microcontroller properly!!

We will be installing the pins and microcontroller on the side of the PCB with the *'Apogee Industries, LLC 2020'* label. The controller will be on the same side as the diodes, with the mini-usb port pointing to the right. (see **Figure 1.4**)

Your molex header pins will either come as one strip that is too long to fit onto the board, or as two strips of 12 pins. If yours is one strip of 24, please clip the strip of pins in half, so that there are enough to fill each hole on the long sides of the microcontroller. (see **Figure 1.3**) Please note that **Figure 1.3** shows the pins on the correct side of the board. The Figure also shows fewer pins than you are provided with. Please use enough pins to fill both sides of the 'U' shaped array of through holes. Once in position, place your Teensy microcontroller on the pins, making sure that the through holes line up with the ones on the PCB. The right side of the microcontroller should be flush with the side of the PCB. (see **Figure 1.4**)

Now that your controller is on the pins, hold it in place and solder the pins to both the PCB and the microcontroller. Assembling it this way avoids issues with misaligned pins. Make sure to apply an adequate amount of solder to each pin!

NOTE: It is *very* important to inspect the soldering on the microcontroller before proceeding. Once installed, the microcontroller cannot be accessed without desoldering the switches!

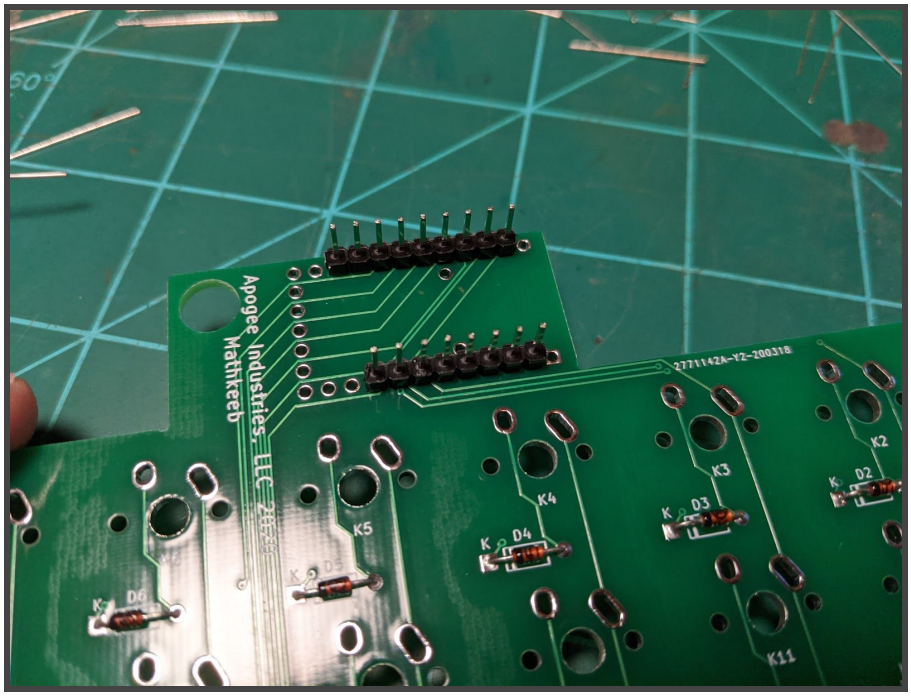

Figure 1.3 - *MOLEX header pins installed on correct side of PCB*

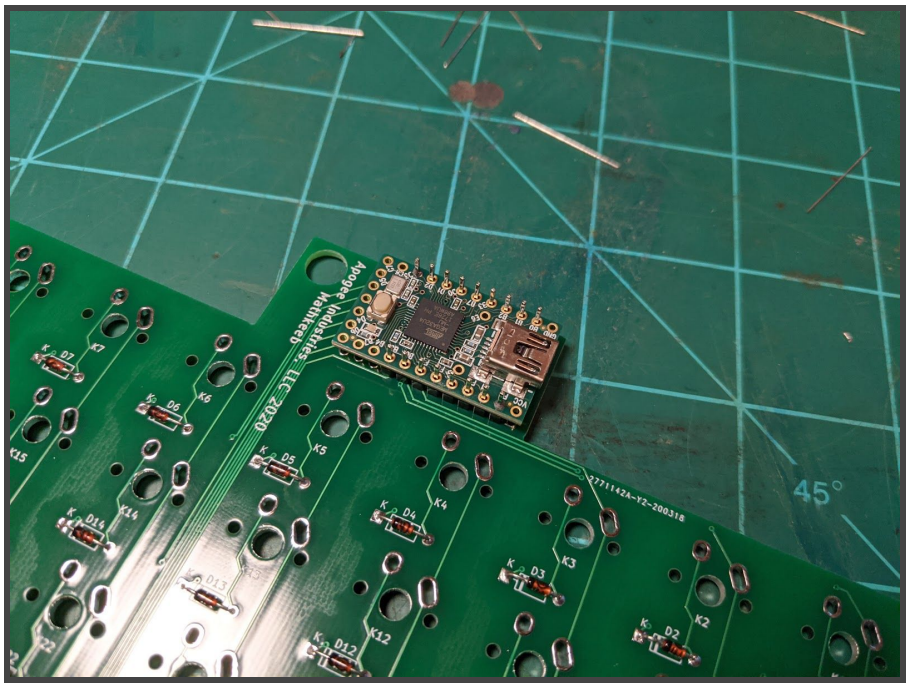

Figure 1.4 - *proper placement of microcontroller*

Switch Mounting

For this section you will need:

1. 54 Kailh Brown switches
2. Mathkeeb Case (upper half)
3. Prepared PCB

At this point we should be finished preparing the PCB for installation. You should have a PCB with all 55 diodes installed, and your Teensy microcontroller properly mounted. *(now is a good time to do one last check and make sure all your diodes are oriented correctly!)* Our next step is to install the switches on the top half of the mathkeeb case (also called the switch plate). This brief section will cover how to properly do so.

Installation of the switches is incredibly easy. Simply take one switch, orient it the correct way, and insert it into a mounting hole until it snaps into place. To determine the correct orientation of your switches, take a look at the pins on the bottom, and orient them so they would line up with the PCB on the side with no diodes. If you are using the Kailh brown switches that came with the default Mathkeeb kit, you would place them on the plate so the Kailh logo is upside down, and the led mounting slot is on the bottom side. (see **Figure 2.1**)

NOTE: Do **not** install a switch in the enter key slot yet! We will install this switch later.

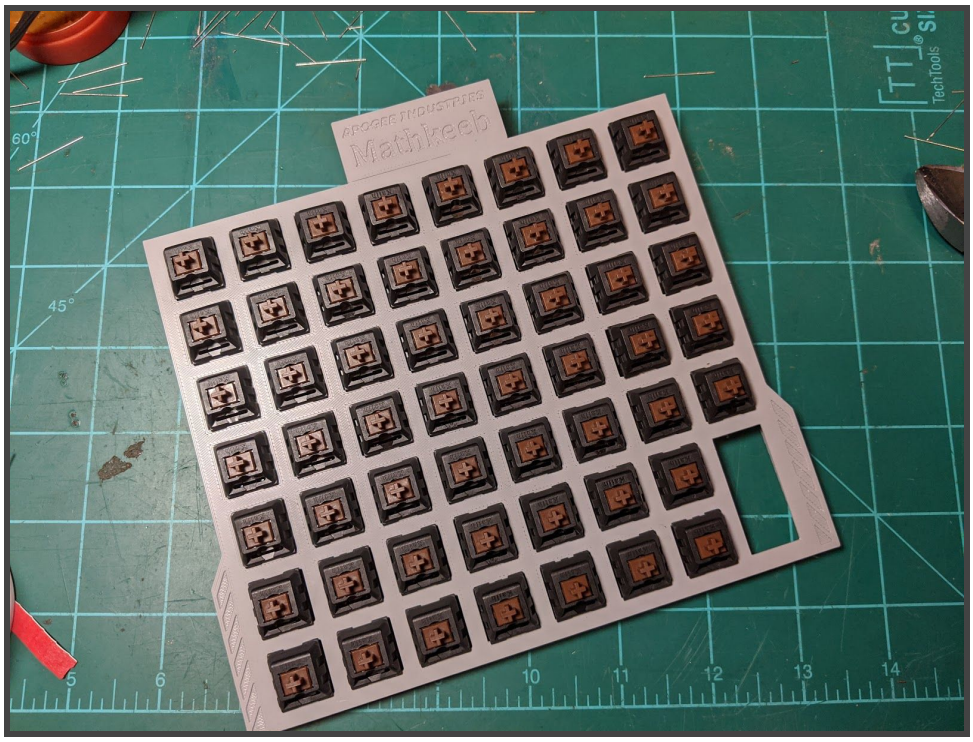

Figure 2.1 - *proper orientation of Kailh brown switches on the Mathkeeb*

Switch Soldering/PCB Installation

For this section you will need:

1. Switch plate with all 1u switches installed
2. Prepared PCB
3. 1 Kailh Brown switch
4. 1 2u key stabilizer

This section will cover the installation of the PCB. This section will require a lot of soldering, so get your irons ready!

To install your PCB, orient it so that the Teensy and diodes are facing down. Then, take the switch plate with all the 1u switches installed, and set it on top of the PCB, making sure that the switches properly index with their corresponding mounting holes on the PCB. Holding the PCB up against the switches, carefully flip the keyboard over and set the board face down, on the switches.

Tip: If your switches fall out while flipping the keyboard over, try setting something (like a piece of cardboard) on top of them to hold them to the plate.

It is recommended to do the soldering on a flat surface, to help keep the switches aligned. After soldering once, you may want to go back and re-solder some of the switches if they are misaligned, or use whatever other method works best for you. When finished, you should have solder around every mounting pin, with no loose switches.

When you are satisfied with the alignment of your switches, flip the keyboard over so it is sitting right side up. We will now install the enter key switch and stabilizer. First, take your 2u stabilizer and set it into the mounting slot as shown in **Figure 3.1** Take your last switch and insert it into the enter key mounting slot. Then, flip the board over, same as last time, and solder the switch in place. You will likely have to readjust the positioning of the switch to get an alignment you are happy with.

Tip: Once the switch is in place, you can use the enter key to align the switch and hold it in place while soldering

When finished, your enter key switch and stabilizer should look something like **Figure 3.2**.

NOTE: You must install the stabilizer *before* installing the switch!

Figure 3.1 - *2u stabilizer in place in mounting slot*

Figure 3.2 - *Switch installed with stabilizer in enter key slot*

Bottom Cover/Keycaps

For this section you will need:

1. (1x) Mathkeeb Case (bottom cover)
2. (3x) m3 6mm screws
3. (55x) Mathkeeb keycaps (54 1u and 1 2u)

Welcome to the final assembly section! You are almost finished assembling your Mathkeeb! This brief section will cover the installation of the keyboards bottom cover and keycaps.

The bottom cover of the mathkeeb is super easy to install and remove. We designed it this way to make repairs as easy as possible. *(we are big fans of right-to-repair so it would be rather hypocritical for us to do otherwise)* The top corners of the bottom cover and the case have an angled face that push up against each other. These close the gap between the two pieces and hold the corners together. To install the bottom cover, simply place it on the Mathkeeb while it is face-down, and slide the cover up into place (towards the microcontroller). Once the cover is on flush with the top, screw in all 3 screws into the threaded inserts. *(be careful not to overtighten!)*

Installing the keycaps is very easy as well, though you should take care while doing so. Take one key and align it with the switch so that the legends are oriented correctly. Then, carefully but firmly push down on the caps so they slide into place. It will take a bit of pressure to get the caps all the way on.

NOTE: If your keycap is not going on, *do not use excessive force!* Check the mount and stem for debris, and try again.

Figure 4.1 provides a diagram of where to install each key for the proper Mathkeeb layout. You can of course rearrange these later on if you wish. For more information regarding reprogramming and creating your own custom layout, please download our Advanced User's Guide from our website.

Mathkeeb Advanced User’s Guide
https://apgind.com/mkadvanced.html

The final step to completing your Mathkeeb assembly is optional, however we do recommend it: Installing the rubber feet! There are 4 feet provided with each kit. We recommend installing them in each corner of the keyboard without covering any of the screws.

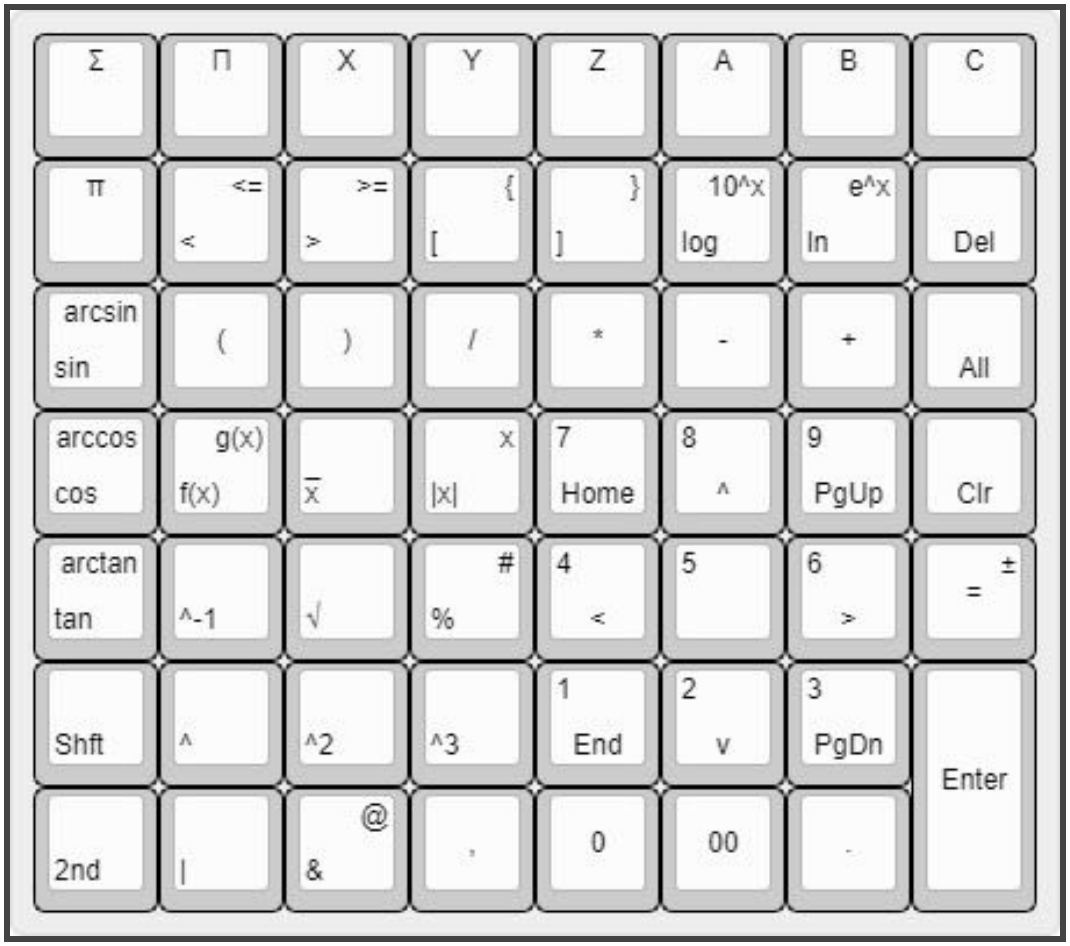

Figure 4.1 - *Mathkeeb keycap layout map*

Congratulations! You have now finished assembling your Apogee Industries Mathkeeb! We hope it proves to be very useful, and that you enjoyed assembling it. At this point it is now safe to plug in the keyboard and test it out! Every kit is shipped with the firmware pre-installed on the microcontroller, so it should be plug-and-play. If you experience any issues on your first test, *DON'T PANIC!* Please refer to the chapter below titled 'troubleshooting'. Thank you again for purchasing a Mathkeeb, we hope you enjoy it!

Troubleshooting

Welcome to the troubleshooting section of this assembly guide! If you are here, it means something isn't quite working right. Don't worry! This chapter will guide you through inspecting the keyboard and fixing anything that may not have been done properly.

Common Issues and How To Fix Them:

My kit was missing parts, or some parts arrived broken - We are very sorry for the inconvenience!

Please contact us using the information on the last page of this guide so we can send you replacement parts as soon as possible!

None of my buttons do anything - The first thing to check in this scenario is the USB cable. Make sure the cable is inserted all the way into the Mathkeeb's USB port, as well as the computer's.

Try your USB cable out on a different Mini-USB device. If this does not work, a faulty cable may be to blame.

If neither fix worked, we will have to open up the keyboard and look at some parts.

First, take a close look at each diode. If you have installed the diodes backwards by mistake, you will have to request an adjusted firmware from us. *(you can also adjust the firmware yourself, but this is only recommended if you know what you are doing!)*

If all of your diodes are in the correct orientation, please take a look at the solder joints on all of the switches, as well as the mounting pins where the microcontroller is mounted. Please note the top of the microcontroller will not be visible without desoldering the switches to remove the PCB.

If everything looks to be in order, please reference the reprogramming section in the Advanced User's Guide at the link above. You may need to reflash the Mathkeeb firmware.

If after all this troubleshooting, your Mathkeeb still won't work, please contact us using the information on the last page of this guide.

One of my buttons or a row of buttons doesn't work - This is one of the most common issues to encounter after assembly. This is typically caused by having used an inadequate amount of solder on the switches. Please check each switch that could be affected, and reapply/remelt the solder as required. Each pin should be fully surrounded by solder and should not be able to move.

If this does not fix the issue, check the orientation and solder on each affected diode. A backwards diode or one without enough solder could cause a whole row to stop working!

One or more buttons only works sometimes - Give the affected switch a good wiggle while pressing it. If it works while being wiggled, it likely needs more solder on a pin. Follow the directions of the problem above.

My problem is not listed here - Please contact us using the information on the last page of this guide. We will try our very best to help you resolve the issue in a timely manner!

Contact information

For more help with troubleshooting, replacement parts, or general questions, please send us an email at support@apgind.com with 'Mathkeeb' in the title, and a description of the issue.

We will try our best to help resolve the issue, or provide a replacement part or keyboard.