A fluorescence microscopy image showing a single cell with extensive spreading. The cell is stained with multiple colors: green, red, and blue. The green signal forms a dense network of fibers, likely representing F-actin. The red signal is more punctate, appearing as small dots or clusters. A large, bright blue nucleus is visible in the center. The overall pattern suggests a healthy, proliferating cell.

Polyfuge User's Guide

Welcome!

Hi there,

Welcome to the Polyfuge User's Guide! If you're here, you're probably interested in some aspect of biotechnology: agricultural engineering, genetics, biopharmaceuticals, or even biomaterials.

In any case, Polyfuge will be a vital asset to your area of study. From nucleic acids to cells, a microcentrifuge will allow you to isolate various substances from solution to assist in your research or engineering goals.

Without further ado - get your gloves on and let's start learning!

Have fun,

Jason Wu
Founder, DoubleGene
Princeton, New Jersey

Thank You to our Backers

Before we start, we just want to give a huge thank you to our **103 Kickstarter backers** who helped raise over **\$7,600** to bring Polyfuge to life. This project would not have been possible without them!



Our **wonderful** backers:

Michael Owen	Lauren V	Ross Cohen	David
David Fan	Gabriel Noe Ross	Elizabeth Tuck	Stephan Zaniolo
Gracious A.	Recovery Force	Brian Weiss	Dr. Sanil Pala
Travis Chan	Mathieu Arnold	Lee Scratchwood	Martin Esser
Robert Cook	Bruce Bock	Sara Edwards	Mitul Shukla
Chris Palmer	John Read	Dustin Collins	Kristina Collins
Mathulan	Allison	Marco Mazzia	Trick-1
K. Edwin Fritz	Ying Zhang	Dan	Chris
Juho Kauppinen	Kevin Cash	Grant Schmarr	Linscott R Hanson
Joe Chen	Fahd	Hung Nguyen	John Sarte
Howard Spergel	Taro Ayabe	Alister Galpin	C. Chenoweth
Alexandra Li	Arthur W. Mingo III	Andy Gallagher	Chai
Alex Liu	Sunil Gupta	Jennifer Thebo PhD	Eli Tamin
Hasso Tepper	Bernardet	Craig Buszka	Karen Loerich
I Yelin	David Schwan	Vincent Goudreault	Michael Choi
Gautier Nadé	8bitviet	NewTripod?	Drewdog
Doug Hurst	Richard Conroy	Stephanie Willing	Zach Fox
Andy Johnston	Joel	Buzz	Jason Sullivan
Brandon R. Piper	Thomas Randall	Mathew Rigoni	mrosenthal
Kermit Henson	Landon	Mohamed Mouratsing	Simon Evanik
Markus Jöbstl	Ross Conover	Erik	Gary Burke
Michael	Matt	Marcos Rodriguez	Tore Brede
Clarissa Redwine	LocksmithArmy	Anita Gray Saito	Üllar Kruustik

Table of Contents

Looking for something? Check out the sections below.

5 General Information

7 Important Safety Information*

13 Open Source File Information

14 Assembly Instructions

59 Operation Instructions

62 Acknowledgements

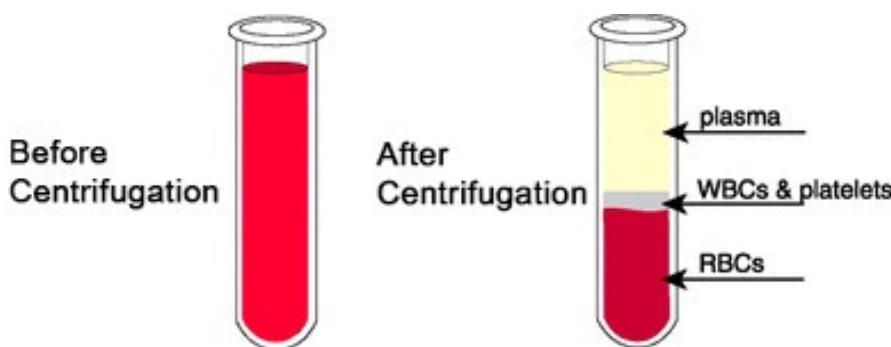
63 Support Information

*Please read this section thoroughly before assembly and operation

General Information

What is a microcentrifuge?

Biological centrifuges are devices used to separate substances from liquid solutions through centrifugal motion. By spinning tubes containing liquid samples at extremely high RPM's, the contents in the tubes become separated by density.



What are microcentrifuges used for?

In clinical settings, microcentrifuges are used to separate blood into its fundamental components: plasma, white blood cells & platelets, and red blood cells (above). In a research environment, microcentrifuges can be used to separate cells from their culture medium, or to extract DNA. The possibilities and applications are endless!

What is the problem?

Traditional microcentrifuges utilize proprietary software and hardware at price points of \$300 up to thousands of dollars, making them relatively inaccessible outside of formal research environments.

What is Polyfuge?

Polyfuge is an inexpensive open-source Arduino-based microcentrifuge created by us - DoubleGene. With its simple user interface and smooth operation, Polyfuge is a DIY microcentrifuge kit truly for everyone.

Where are the files?

Links to the open-source files can be found on our website: www.doublegene.com

How do I get started?

First off, make sure to read through the “Important Safety Information” section on the next page before continuing. After that, open your Polyfuge kit and start assembling with the instructions on page 14!

Important Safety Information



Warning: Centrifuges are versatile tools, but can be dangerous when handled incorrectly. Please closely read through this section before continuing any further.

Disclaimer

We are not responsible for damages, injuries, deaths, or other ill effects arising from proper or improper use of or assembly of the Polyfuge components. To the fullest extent permissible by the applicable law, we hereby disclaim any and all responsibility, risk, liability, and damages arising out of death or personal injury resulting from assembly of or operation of this kit.

Polyfuge User's Guide Version 1.0 4/18/18

Balancing Tubes

It is extremely important that any centrifuge is balanced before use. When placing a tube within the Polyfuge rotor, another tube of equal weight/volume must be placed directly across in order to “balance” the rotor. **Failure to do so will result in an imbalanced centrifuge, which can both destroy the machine and harm people around it.**

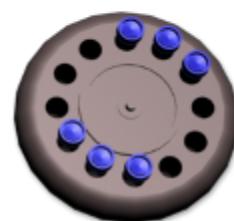
Examples of Balanced Configurations:



2 tubes

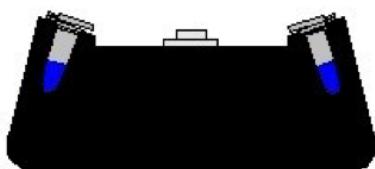


4 tubes

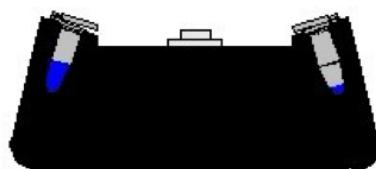


6 tubes

In cases where an odd number of tubes must be centrifuged, we recommend making a “balance tube” by filling a centrifuge tube with a volume of water equal to the tube directly opposing it.



✓ Tubes are balanced



✗ Tubes are not balanced

Still not sure how to balance?

If you are still unsure of whether a certain balancing configuration will work or just need some more in depth information on balancing tubes, check out this article on safe balancing by wikiHow:

<https://www.wikihow.com/Balance-a-Centrifuge>

Never run a centrifuge if you are unsure whether the tube configuration is balanced. Consult a professional or contact us through the support contact on page 63.

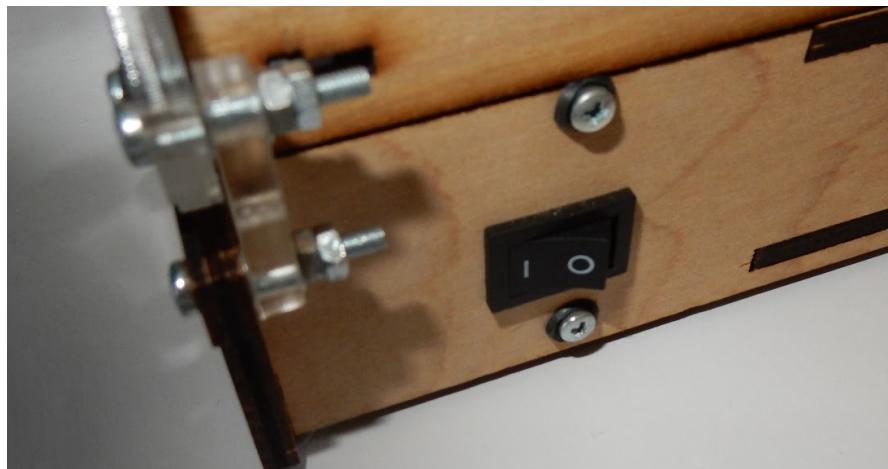
Tube Compatibility

Polyfuge is only compatible with 1.5 mL microcentrifuge tubes. These tubes can be purchased on Amazon for roughly \$15 for 500 non-sterile tubes. Please do not attempt to use any other tube size with Polyfuge.

My Polyfuge is shaking violently and making loud noises! What do I do?

If you notice that Polyfuge is vibrating violently or emitting loud clanking noises, press the control button on the front of the device **immediately** to cancel the run.

In the event that this fails, press the rocker switch on the back of the device to cut power to the device completely.



Violent vibrations and loud crashing noises are almost always caused by an unbalanced rotor. Thus, it is absolutely necessary to cancel the run or shut off the device as soon as this unusual behavior occurs. **Never leave a centrifuge unattended!**

Leakages and Spills

In the event of a tube leakage or spill, cancel the run and shut off the device immediately.

Keep Polyfuge away from all liquids. Water can damage the electronics, and some liquids have the ability to destroy the frame. All parts exposed to liquid during spillage should be replaced before further use.

Transport/Drops

While Polyfuge is suitable for careful use, severe drops or reckless transport can cause the frame or interior components to break.

Make sure that Polyfuge is handled with care!

Handling the Lid and Rotor

Please ensure that you **do not touch the exposed rotor while it is still spinning**.

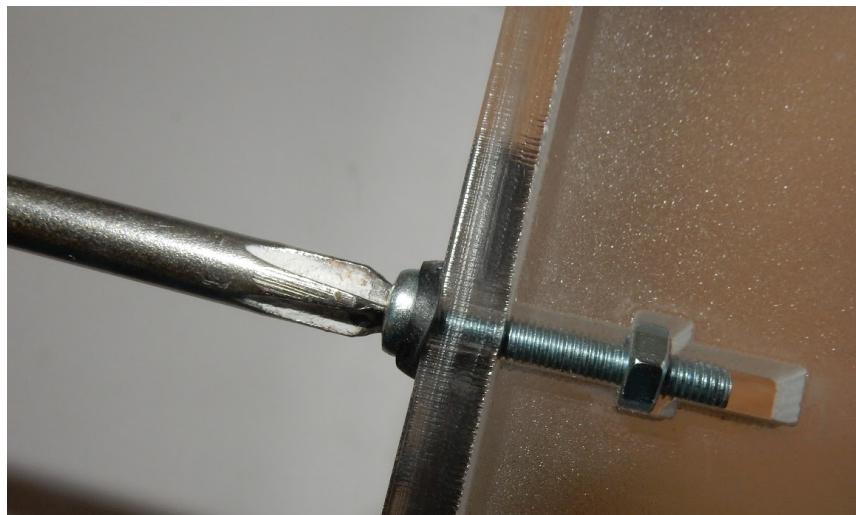
Please wait until all rotor movement stops before opening the lid and removing/inserting tubes for a run.

Keep the lid closed at all times when the rotor is in motion. The high RPM's of the rotor can cause significant damage when physically disturbed - keep your fingers away!

Strong Assembly = Safe & Happy Spinning

While constructing Polyfuge, ensure that all nuts, bolts, and mounts are **sufficiently tightened** (especially the rotor).

It's also important to service your Polyfuge unit every now and then, as the vibrations from centrifugation can loosen the nuts and bolts over time. We recommend checking the tightness of the nuts and bolts at least once a week, and tightening them as needed.



Run a Safety Test After Assembly

Once you are done assembling your Polyfuge unit, make sure to run a quick safety test to ensure that all of the safety interlocks are functioning properly. Check out the safety test instructions on page 53.

Spread the Word!

Make sure that all friends, labmates, or family that use your Polyfuge unit read through the safety information as well!

Open Source File Information

Where are the files?

All of our files will be available for download on our website: www.doublegene.com

These files include all of the components you need to create your own Polyfuge - a bill of materials, vector and stl files, PCB EAGLE files, and even our custom lab education protocols!

How do I make the frame?

Our Polyfuge frame can be both 3D-printed or laser cut. For 3D-printing, we recommend printing with ABS filament, though PLA is still sufficient at high infills. Laser cut panels can be cut from either acrylic or wood depending on your preference!

Assembly Instructions

With these instructions, you'll be able to assemble your own Polyfuge kit within a span of only 2-4 hours.

Make sure to take some breaks, pay close attention to the steps, and to be gentle with the components. If you want, have a friend or family member lend you a hand!

Have fun!

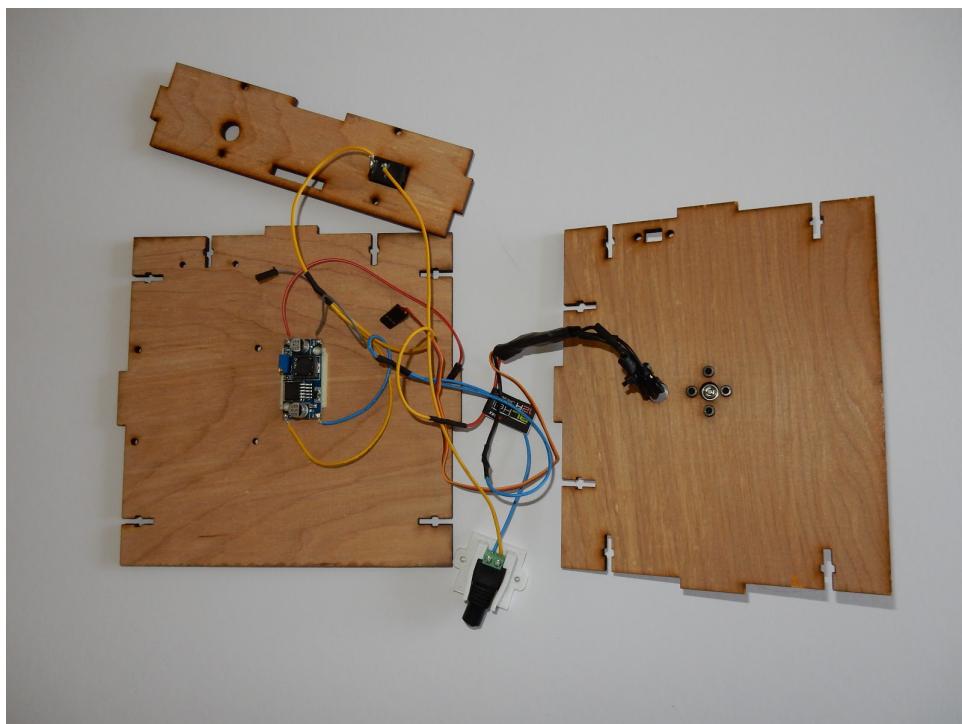
You will need

- Phillips-head screwdriver
- Pliers
- Hex keys

Making the Base

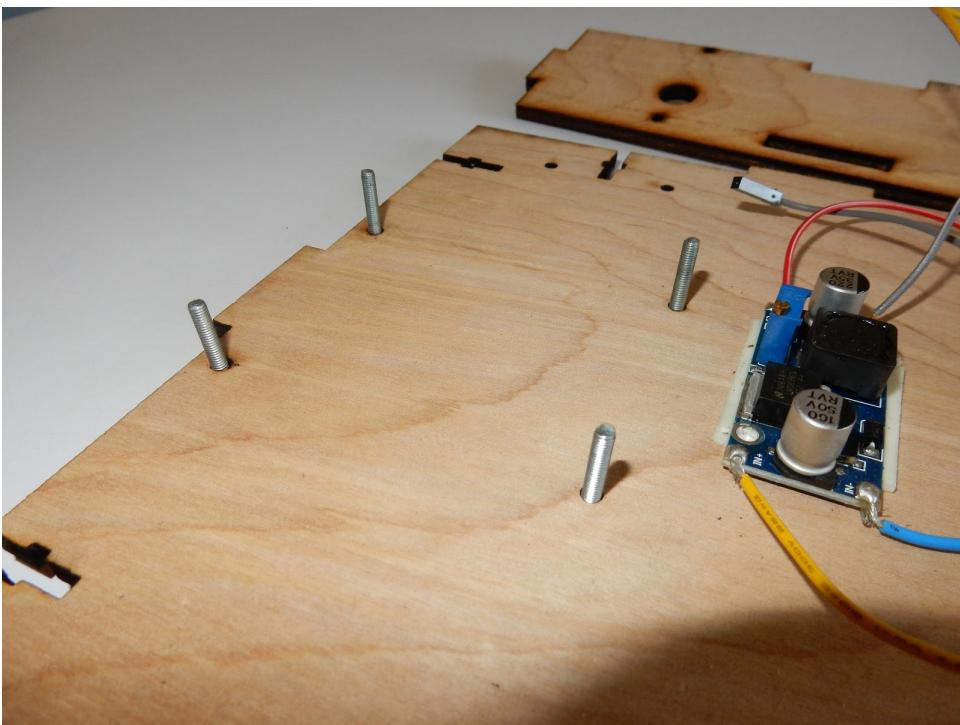
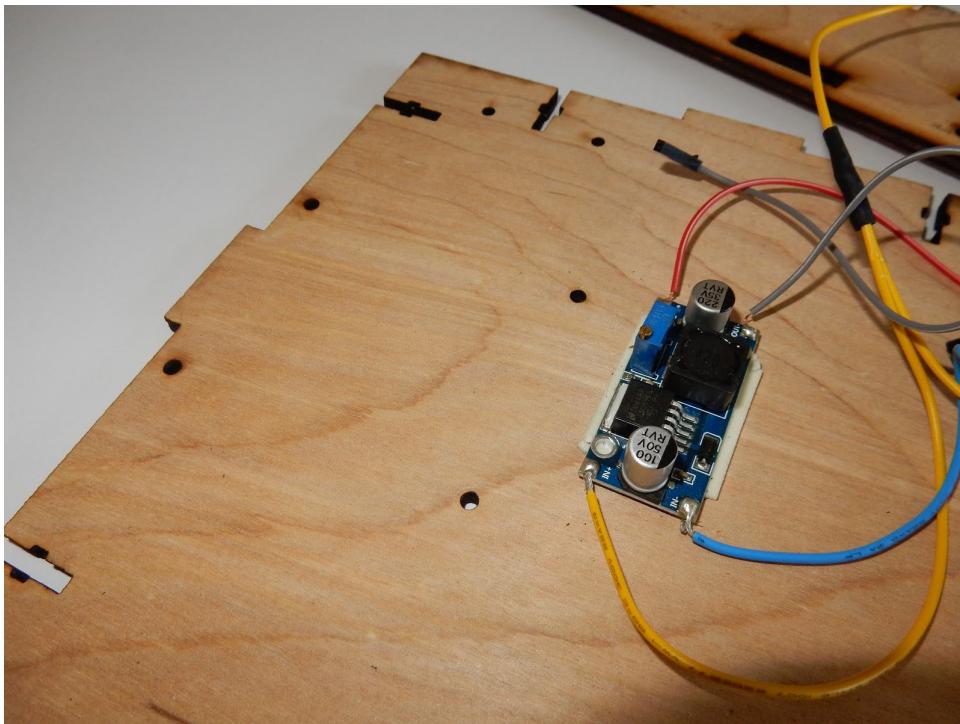
1

First, let's locate the main base complex! All of the electrical parts have been pre-soldered, so we are going to focus on assembling the frame.



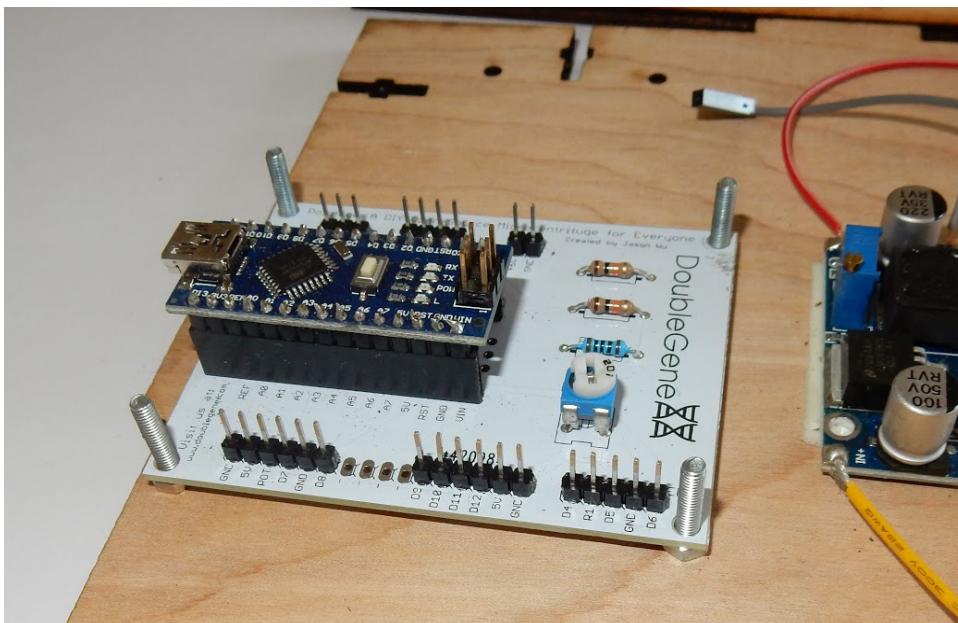
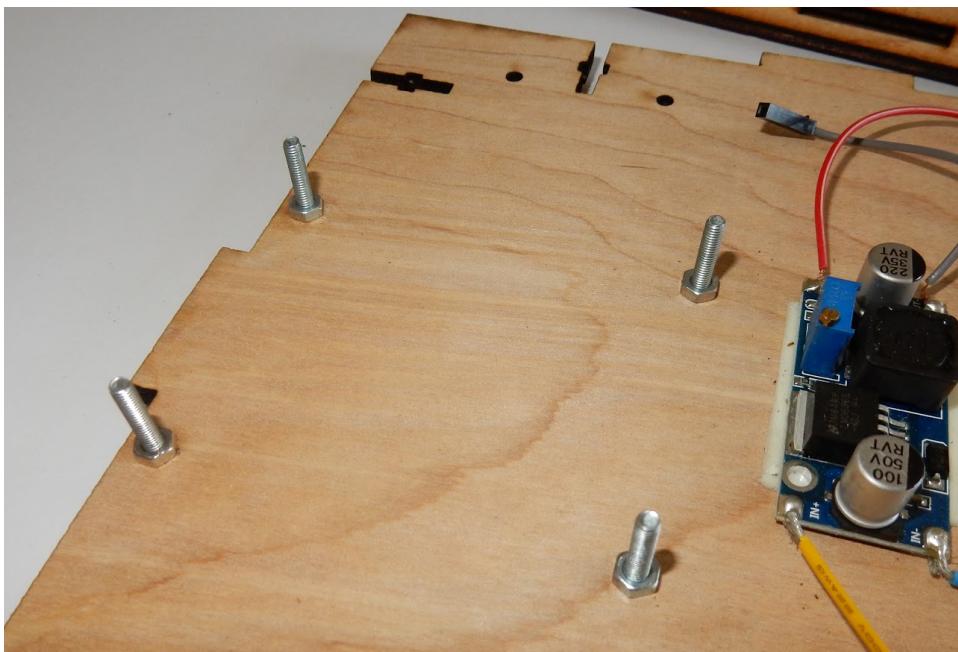
2

Now that we've located the main base complex, let's mount the Polyfuge circuit board on the base. Put four 20mm bolts through the mounting holes so they are facing upwards like so:



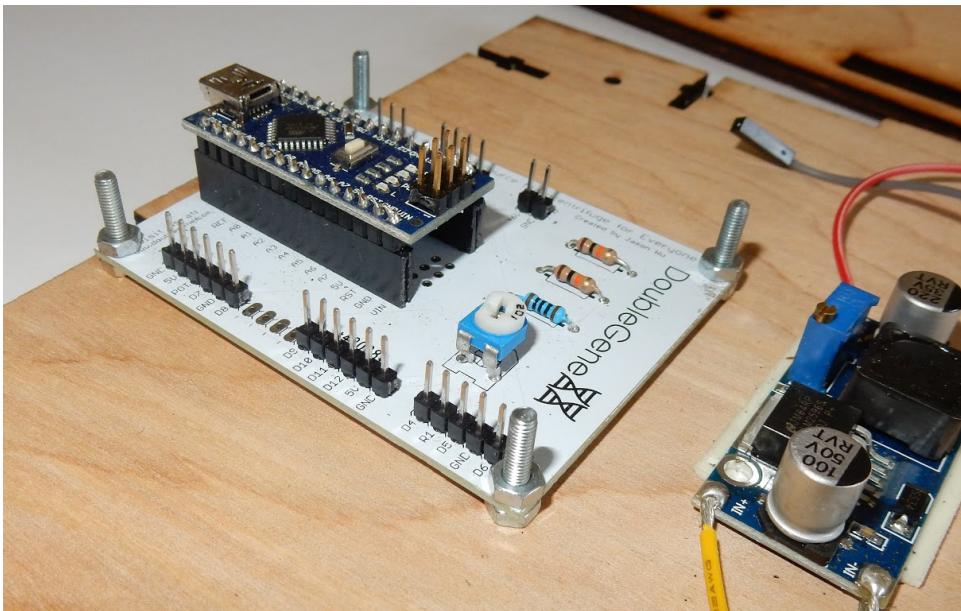
3

Next, thread four M3 nuts on the bolts, and place the circuit board on top.



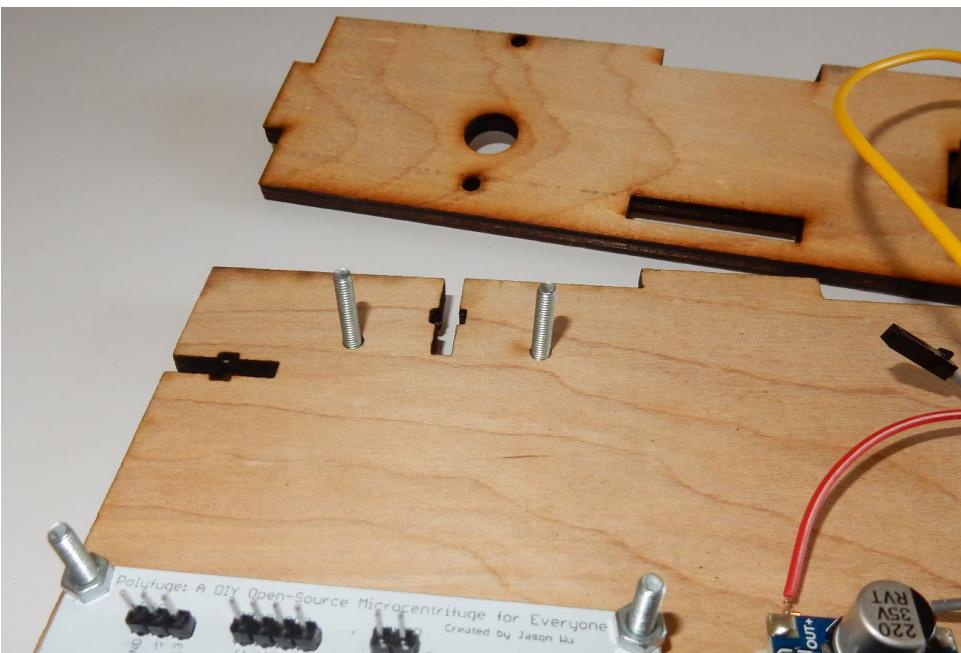
4

Finish the circuit mounting process by adding four more nuts!



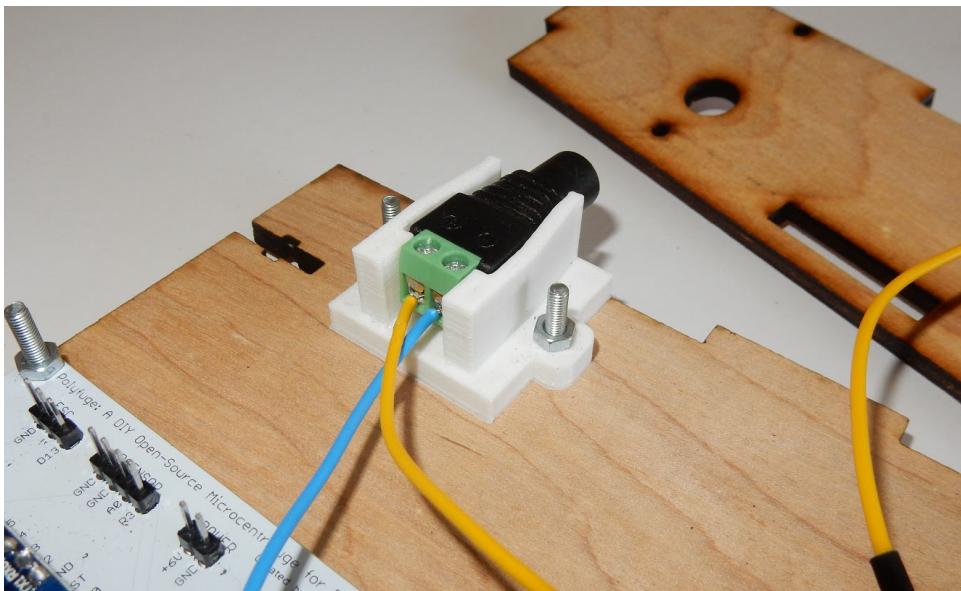
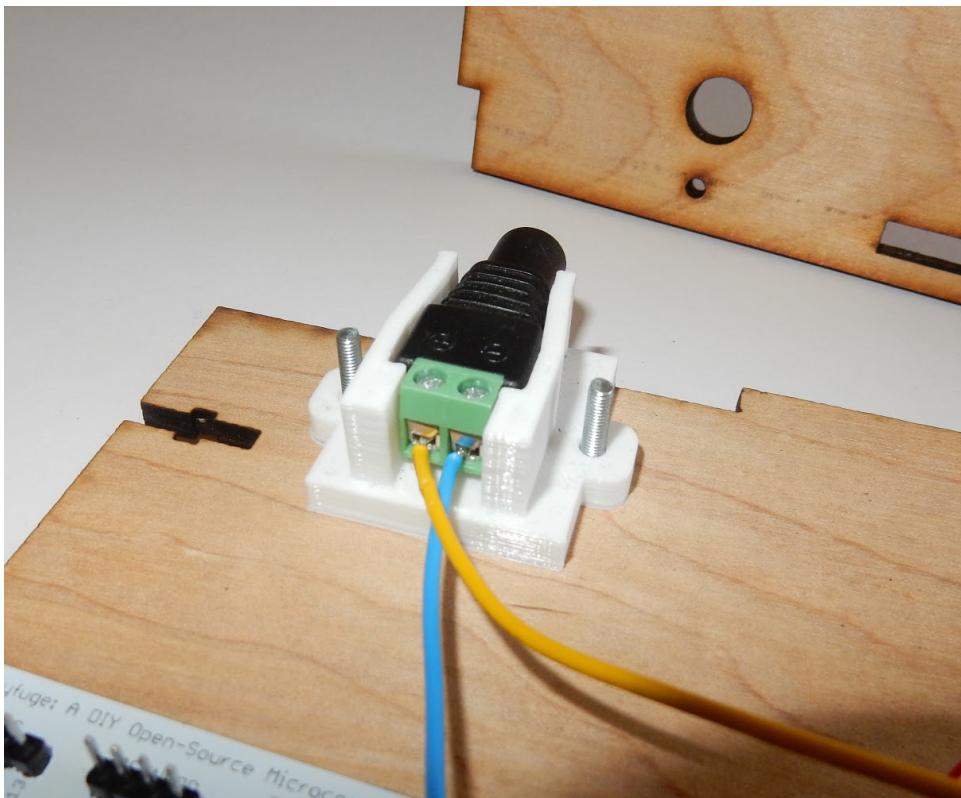
5

Add two more bolts to the upper left hand corner to mount the female barrel jack.



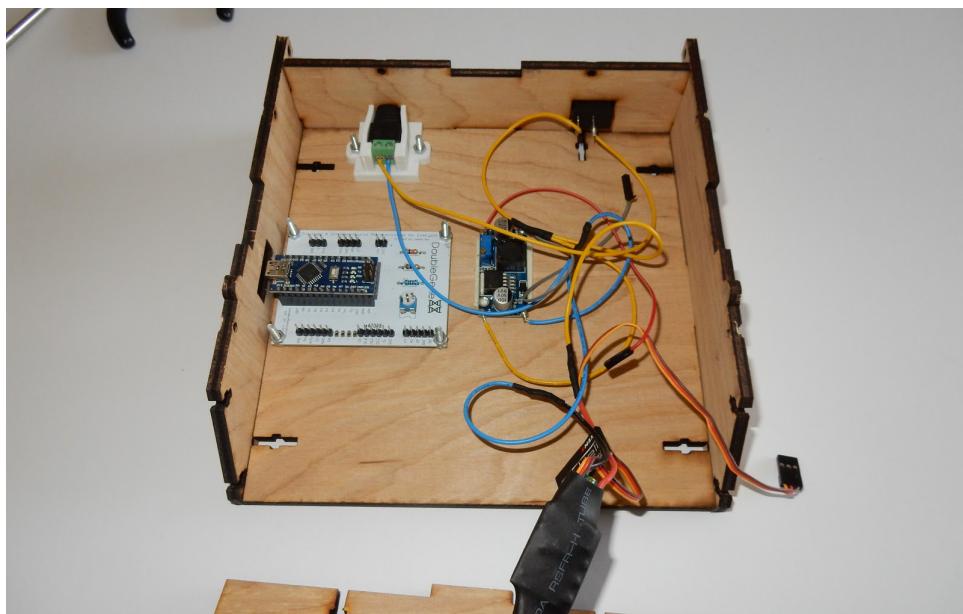
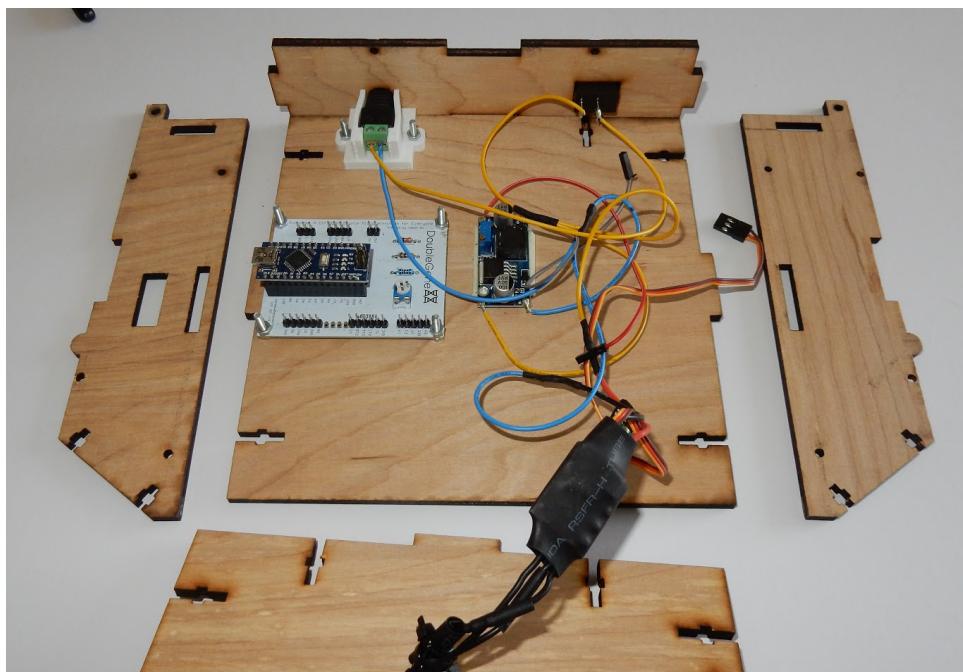
6

Mount the female barrel jack, and slip on two more nuts to secure it.



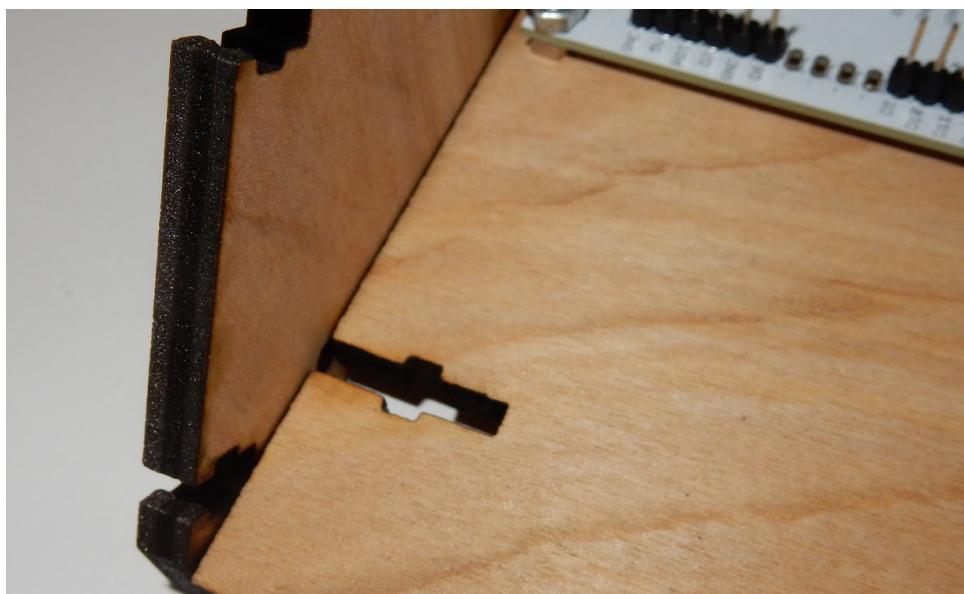
7

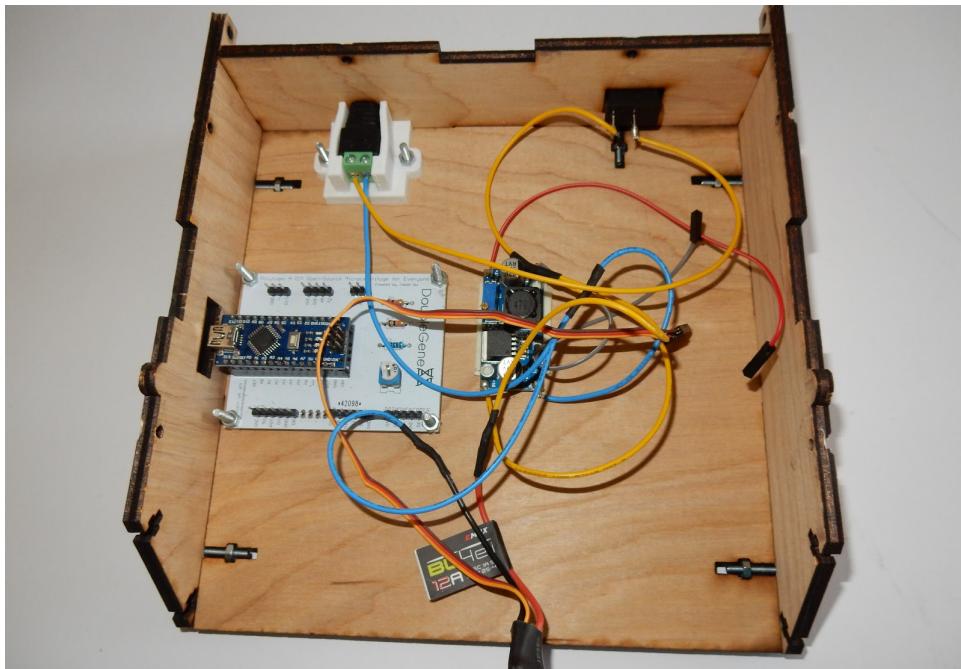
Good job! We've finished mounting components to the base. Now, locate the two side panels and place them in the configuration shown below:



8

Now, we are going to secure the panels to the base. Place a rubber washer on each bolt, and connect the panels together by using the T-slots like so:





9

Things are starting to come together! For this next part, locate the front base panel.



10

Mount the rotary encoder by putting it through the hole and threading the large nut like so:



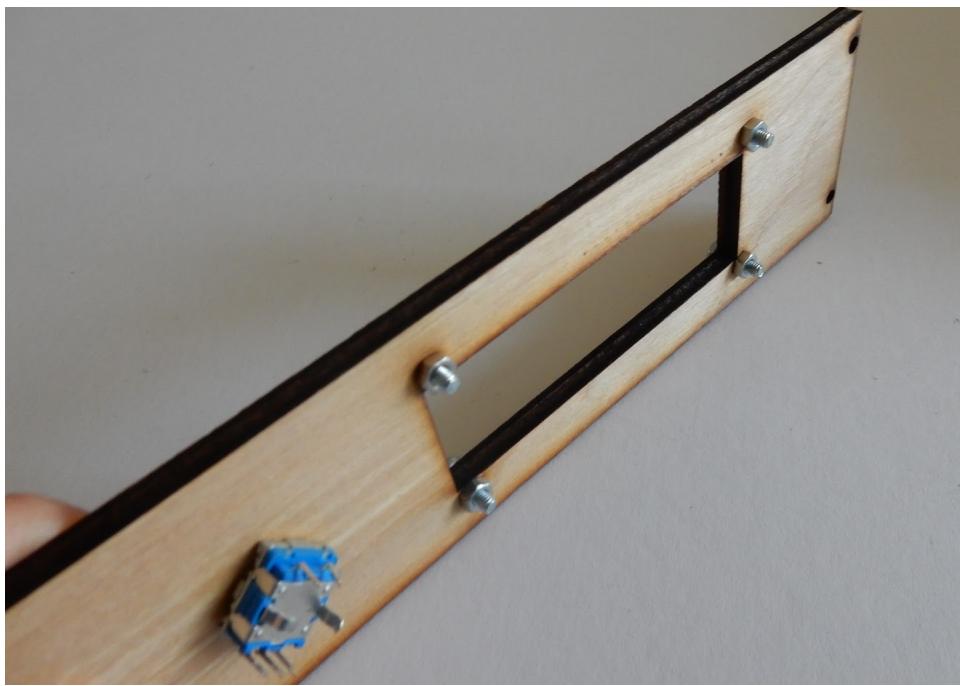
11

Now we are going to mount the LCD! Put four 10mm bolts through the front panel.



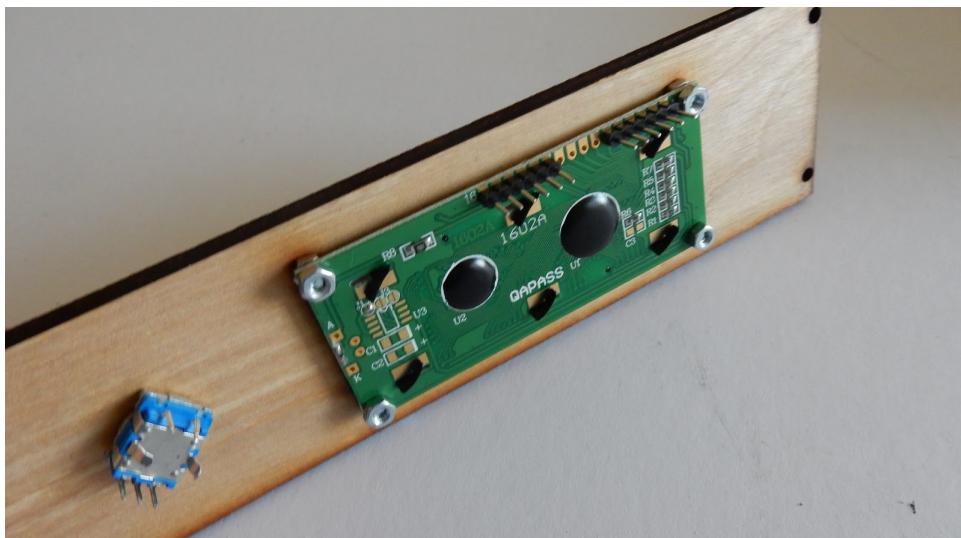
12

Put another four nuts on the bolts like so:



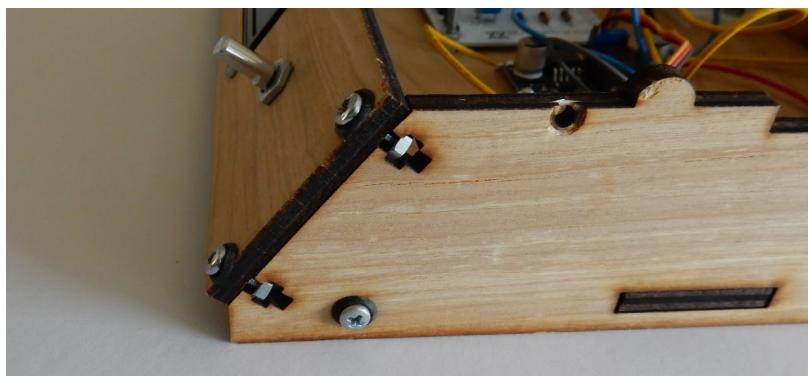
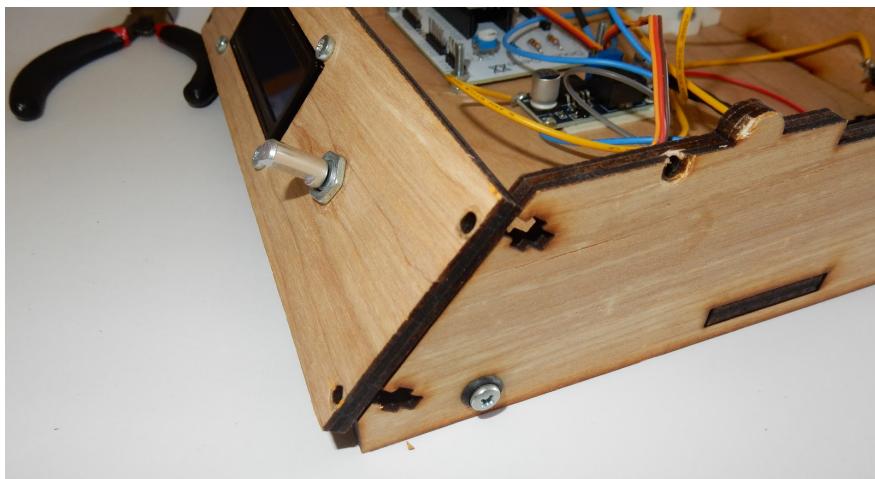
13

Place the LCD on the front panel and add four nuts to secure the component.



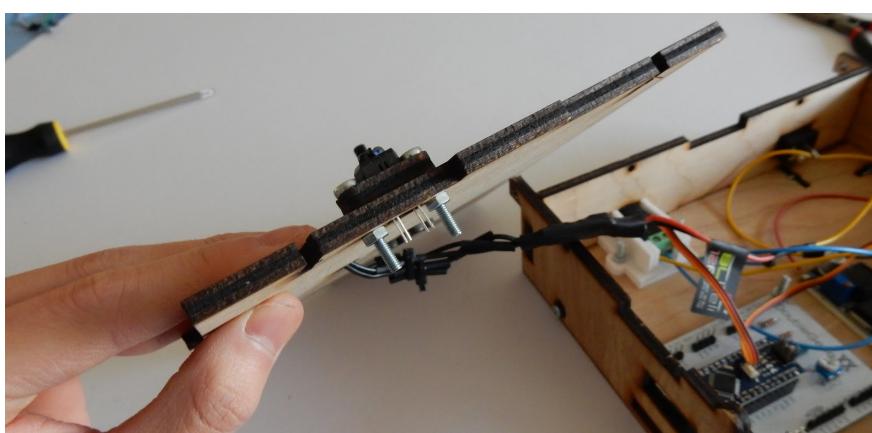
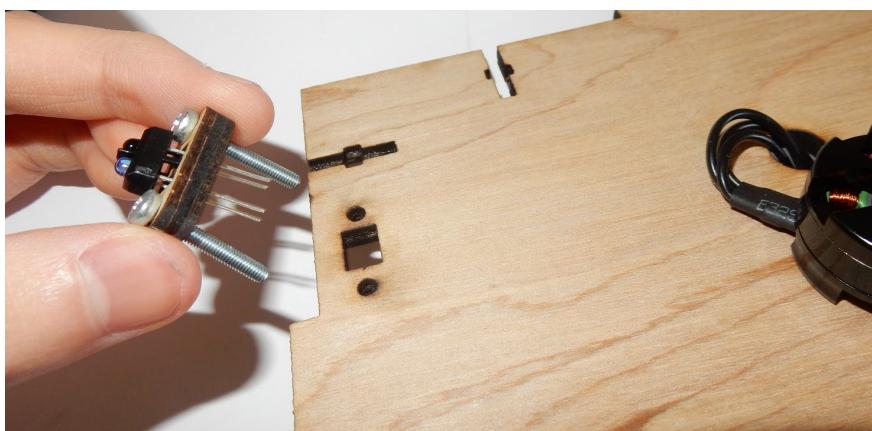
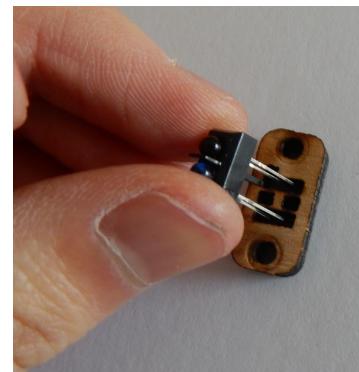
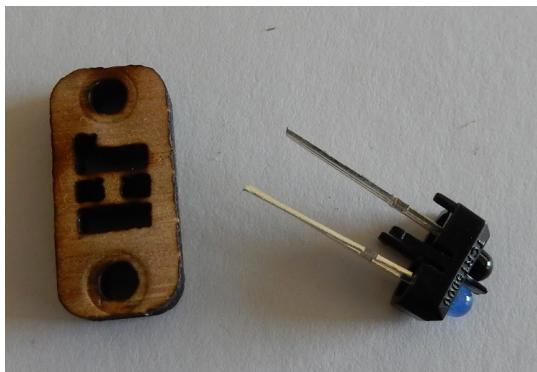
14

Now, let's mount the front panel to the rest of the base: place rubber washers on four 10mm bolts, and secure the front panel to the base with nuts through the T-slots.

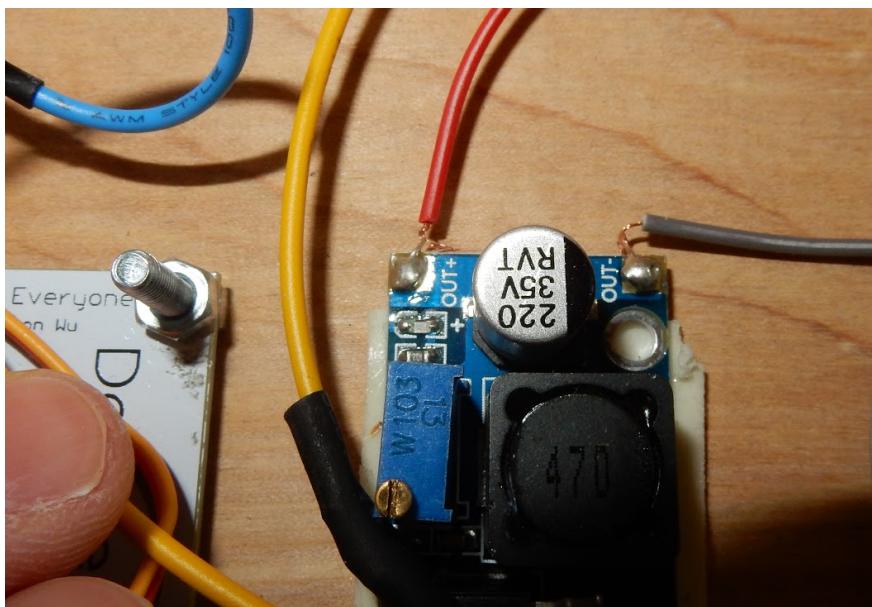


15

Next, let's work on the IR sensor! Place the IR sensor into the mount and secure the whole complex to the base top with two 20mm bolts and M3 nuts.

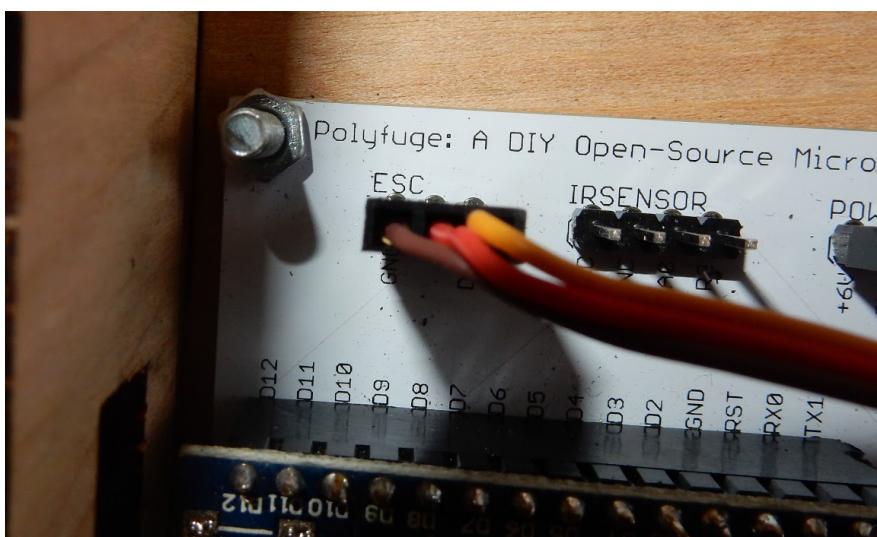
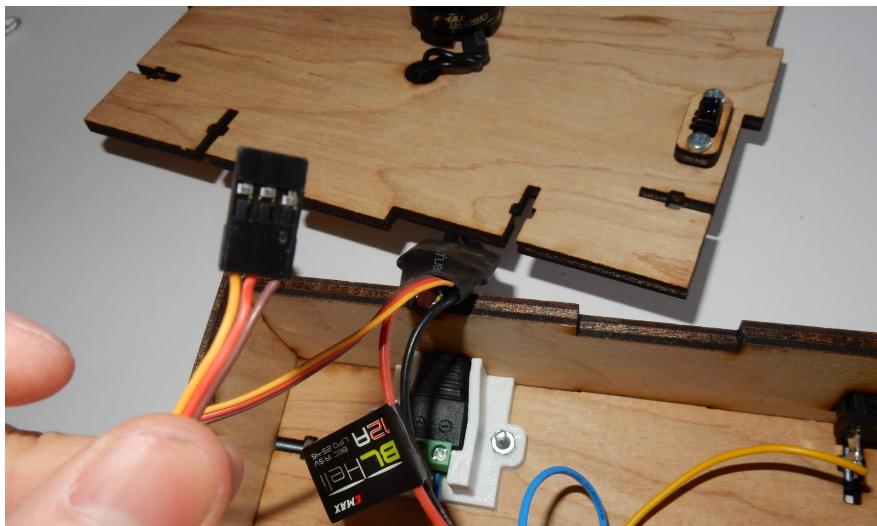


Time for the hard part: hooking up the electronics. First off, hook up the output and GND of the voltage regulator to the POWER pins on the Polyfuge board. (OUT+ connects to 6V+, and OUT- connects to GND).



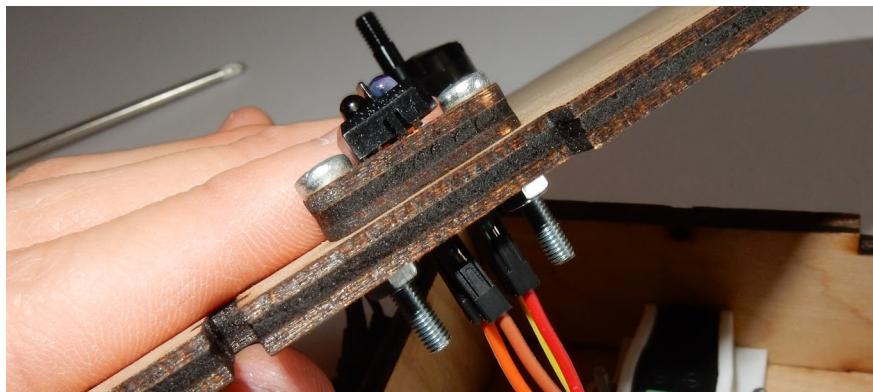
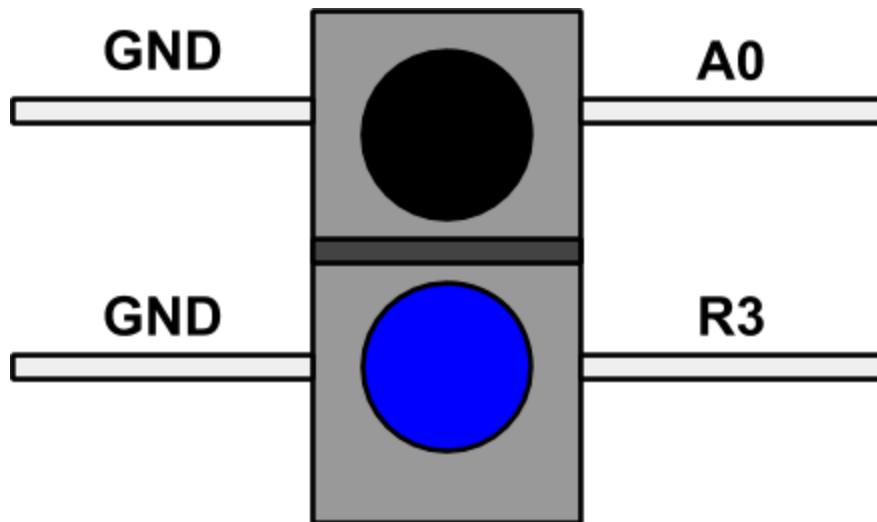
17

Next, plug in the motor to the ESC pins on the Polyfuge board. (Brown wire connects to GND, and yellow wire connects to D13).

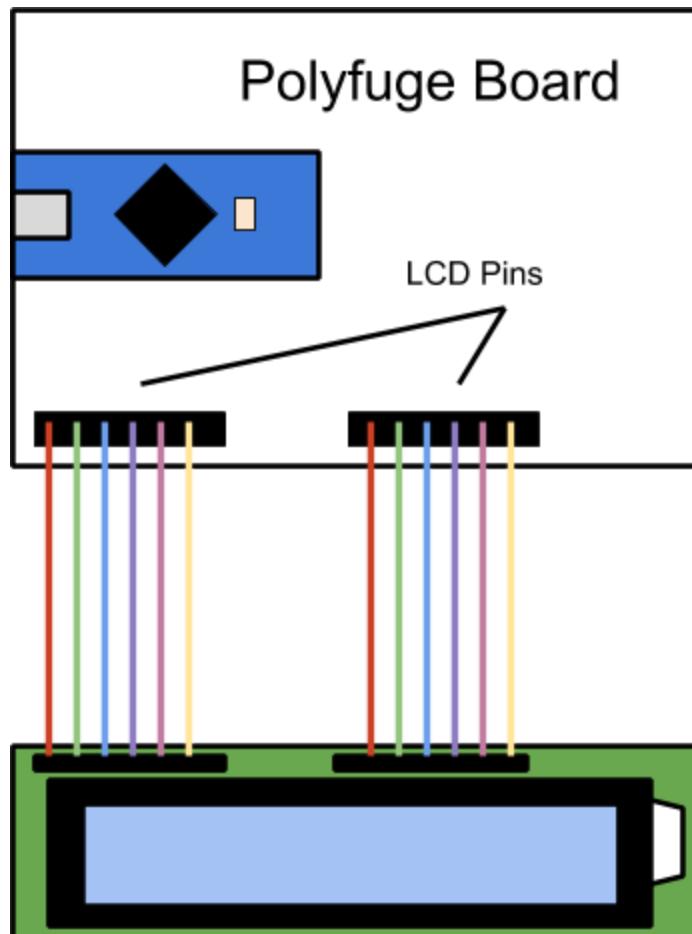


18

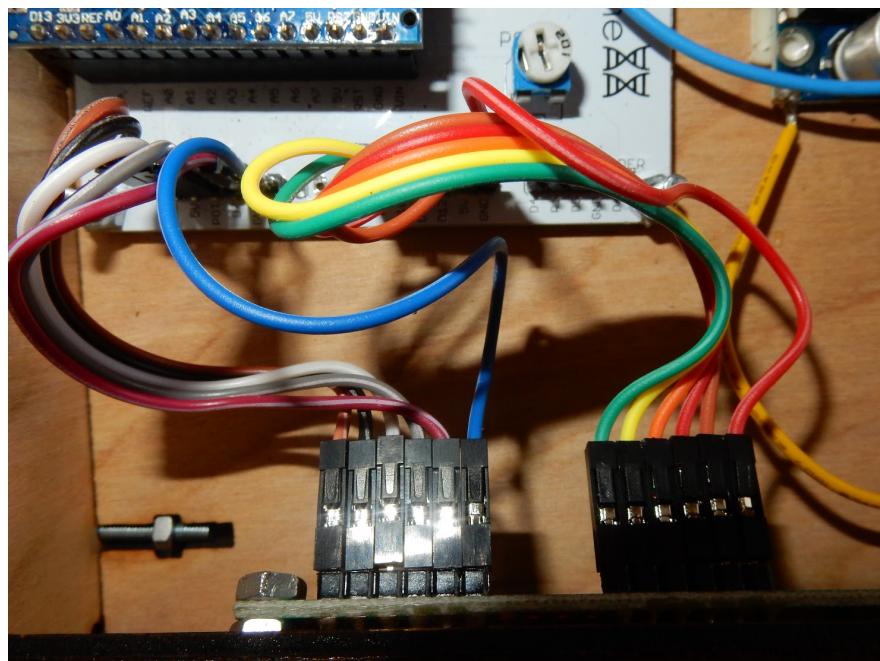
For the IR sensor, use the female-female jumper wires to connect the leads to the IRSENSOR pins on the Polyfuge board. Connect each lead in the following configuration:



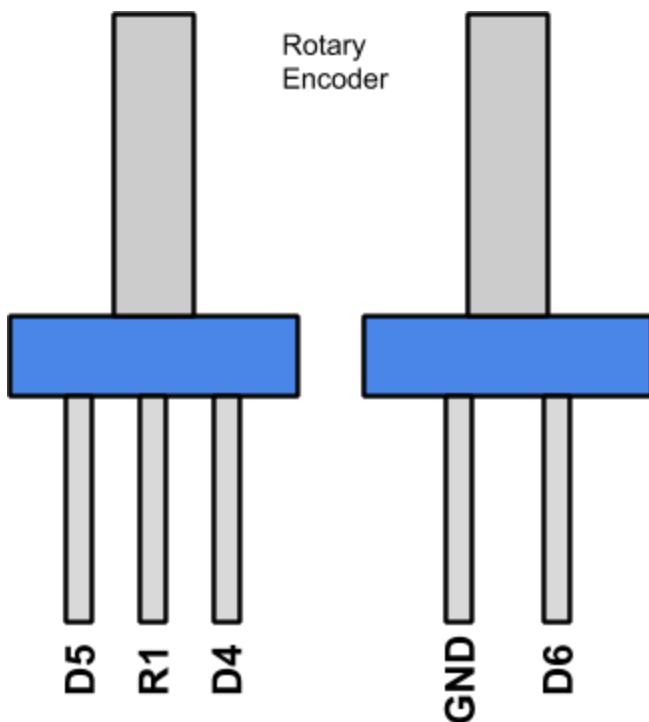
Don't worry, we're almost done! Hook up the LCD to the LCD pins on the Polyfuge board with female-female jumper wires in the following configuration:

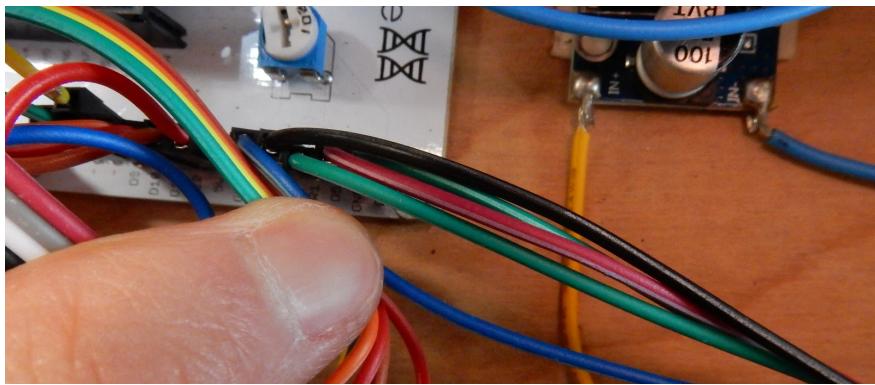
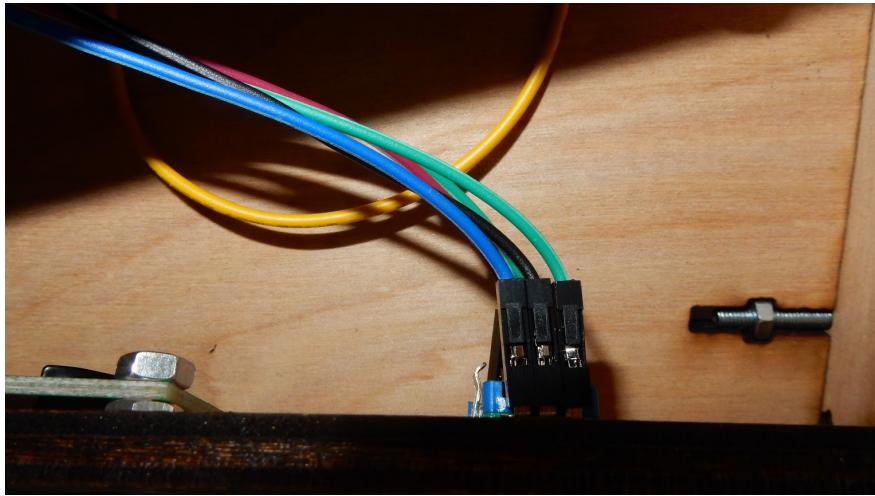


20



Finally, let's hook up the rotary encoder to the ROTARYENCODER pins on the Polyfuge board with female-female jumper wires in the following configuration:

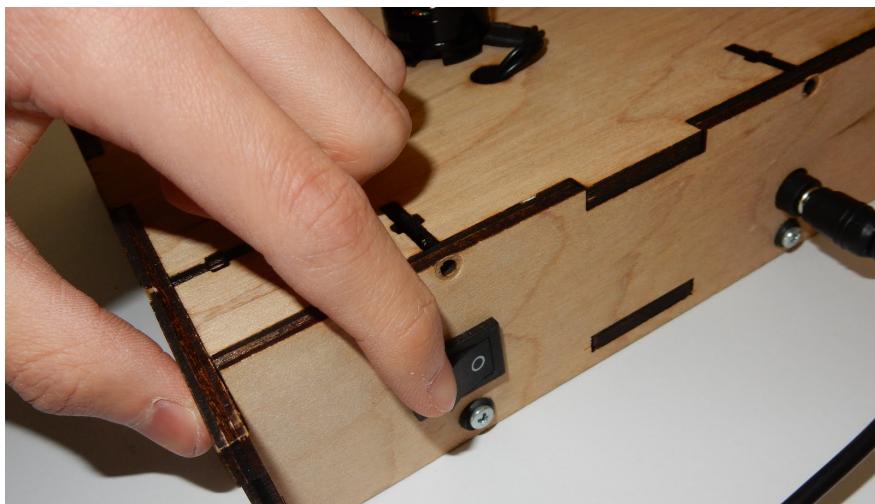


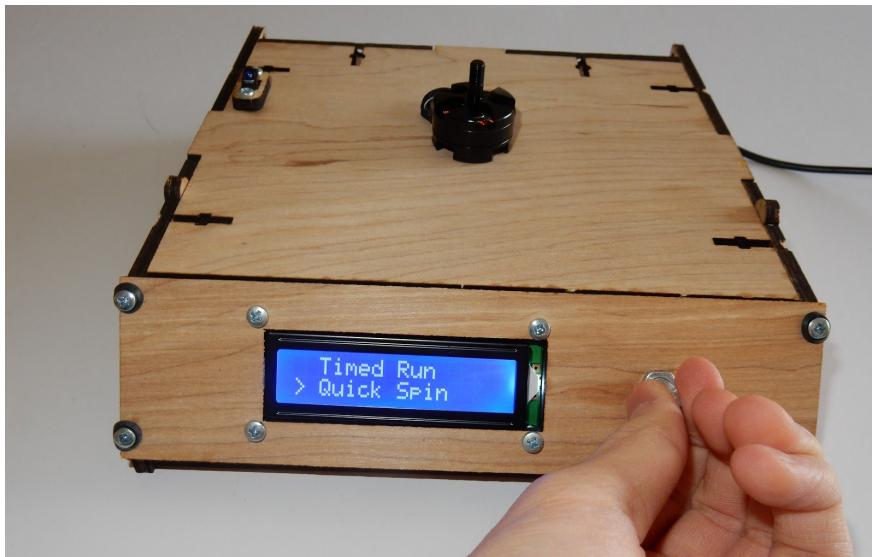


21

Before we go any further, let's run a quick electronics test! Place the top base panel on the rest of the case. Plug in the female barrel jack, flip the power switch, and make sure that everything is working.

If you don't see anything on the screen, try adjusting the screen contrast with the potentiometer on the Polyfuge board.





22

If everything works, we're done with the electronics!

23

Now, let's assemble the rest of the base. Make sure that the motor is secured to the base top panel, and place the panel in place.



24

Now, place rubber washers on six 20mm bolts, and secure the top panel with nuts through the T-slots.





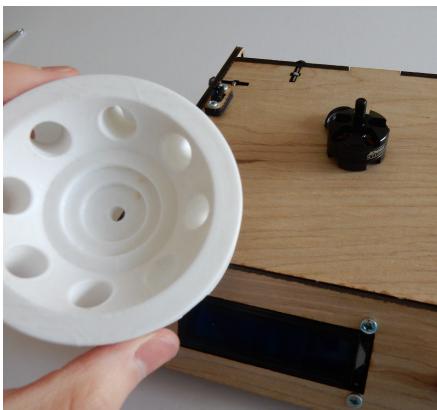
25

Finally, let's mount the 3D-printed parts!
Place the rotary encoder cap on the device
like so:



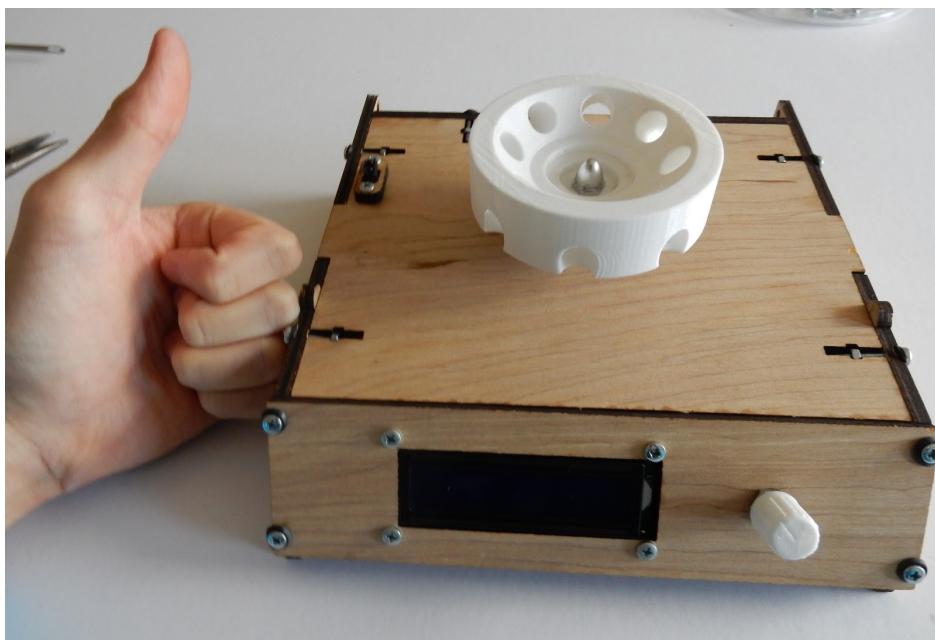
26

Now, let's mount the rotor by placing it on the motor shaft, and securing it tightly using pliers and the threaded motor cap. Make sure the rotor is leveled!



27

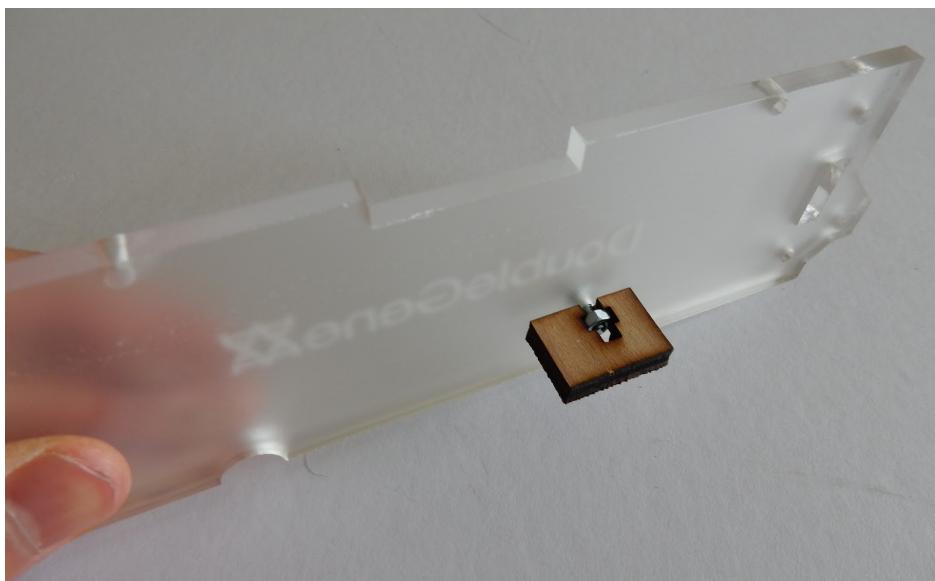
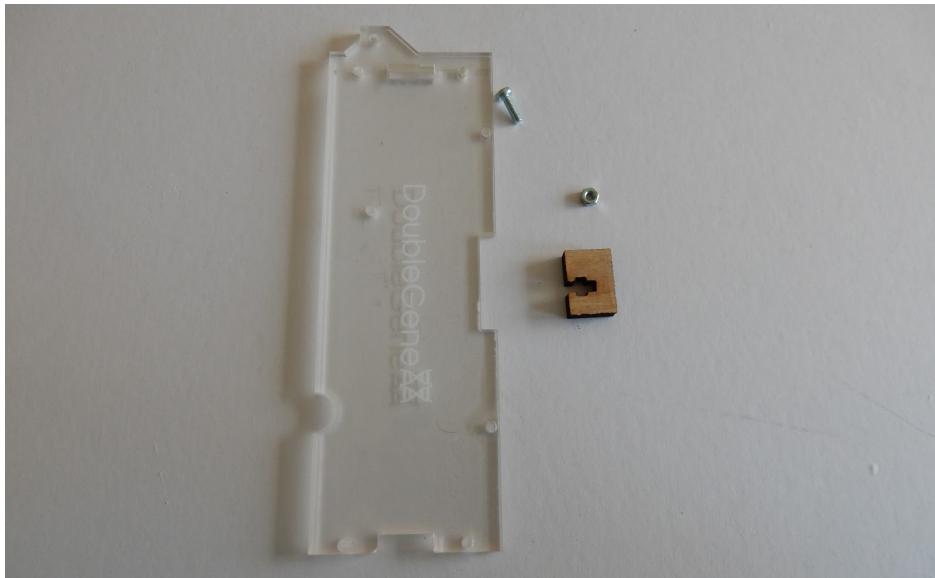
Good job - all done with the base! Take a short break before moving on to the next steps. You deserve it!



Making the Lid

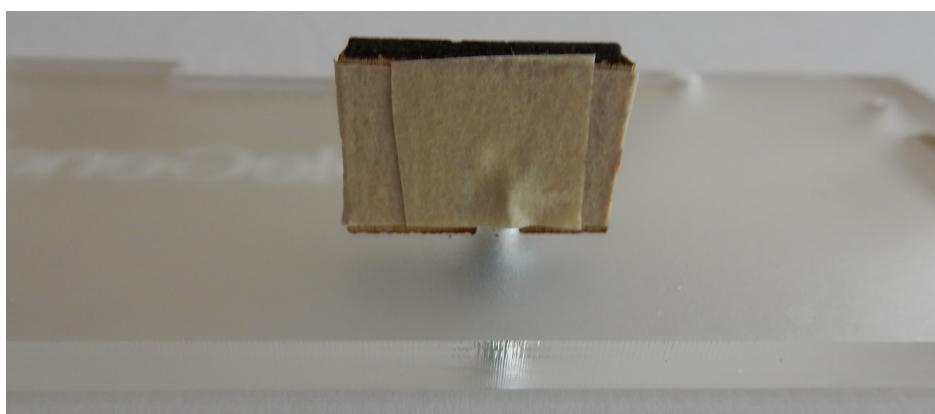
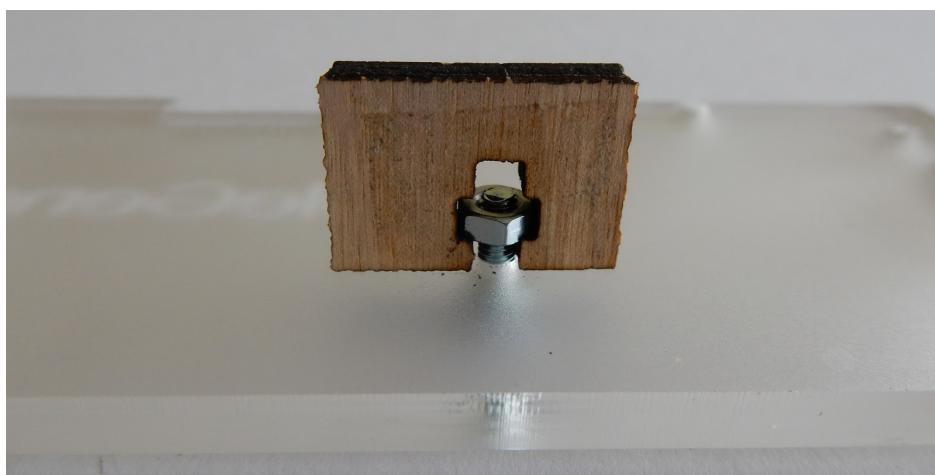
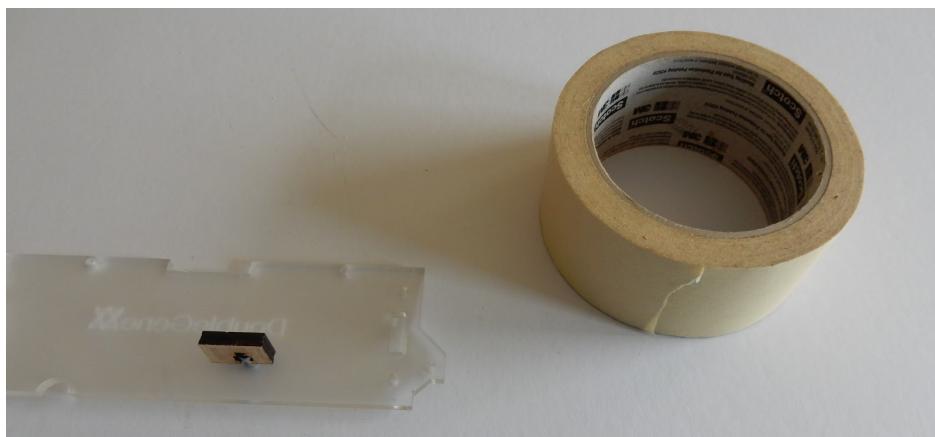
28

Locate the left lid panel and mount the IR cover using a 10mm bolt and M3 nut.



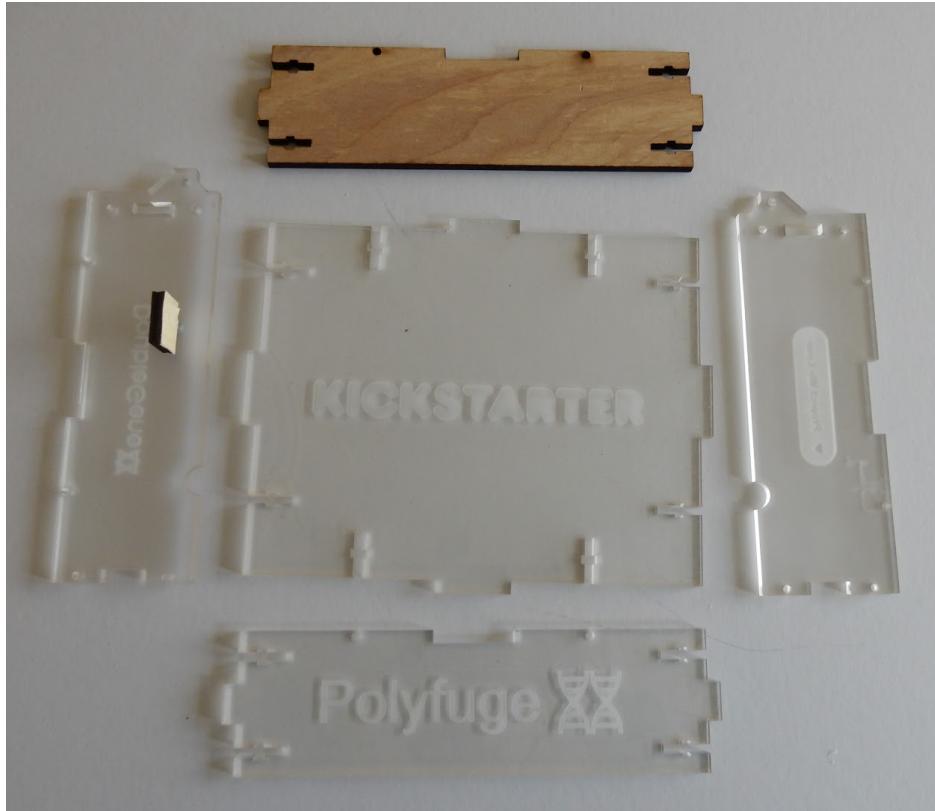
29

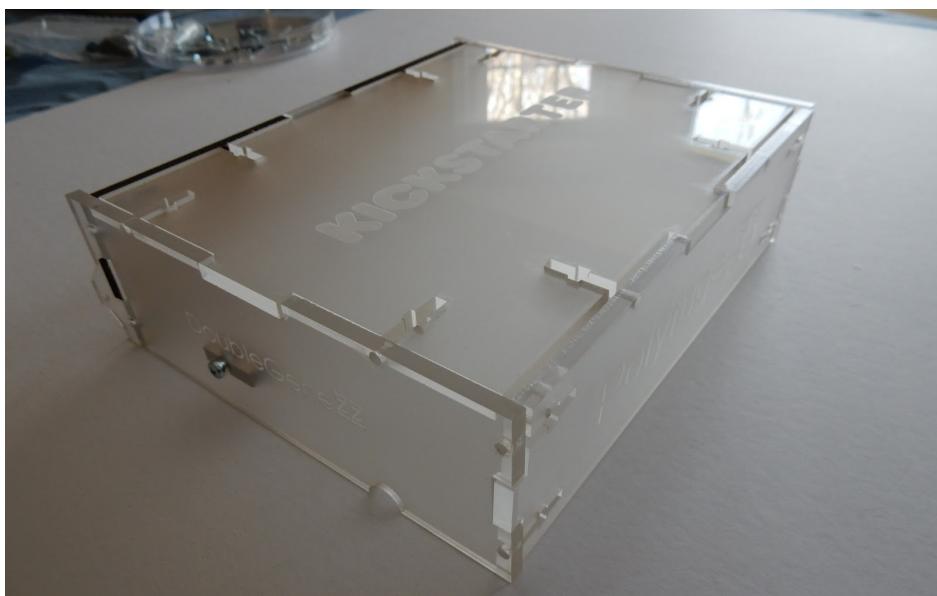
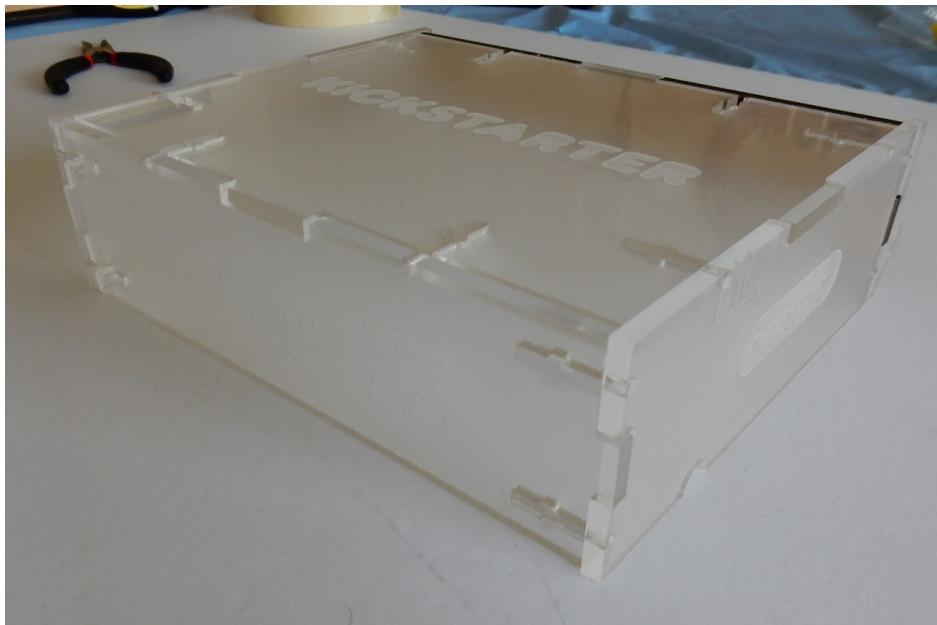
Place a piece of reflective or masking tape over the bottom of the cover - this is to ensure that the IR sensor detects the lid when it's closed. Do not use electrical tape!



30

Place all of the lid panels in the following configuration.

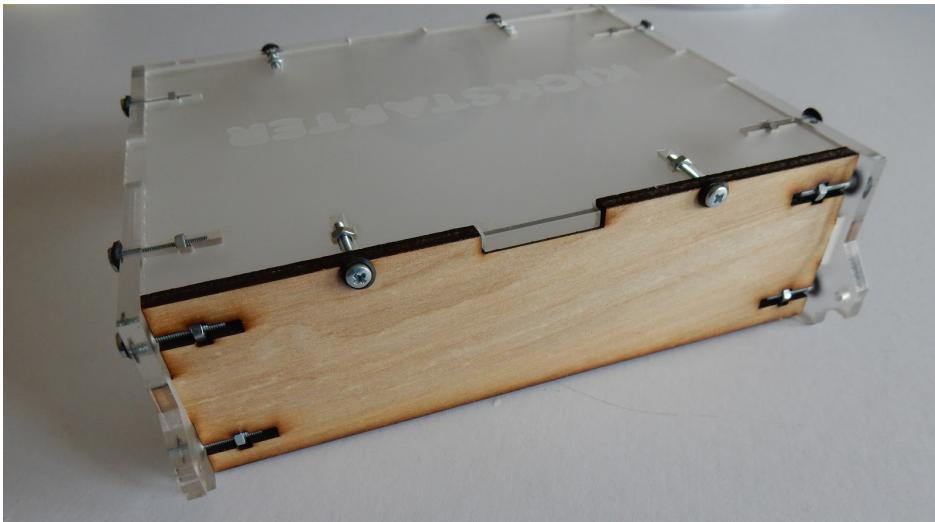




31

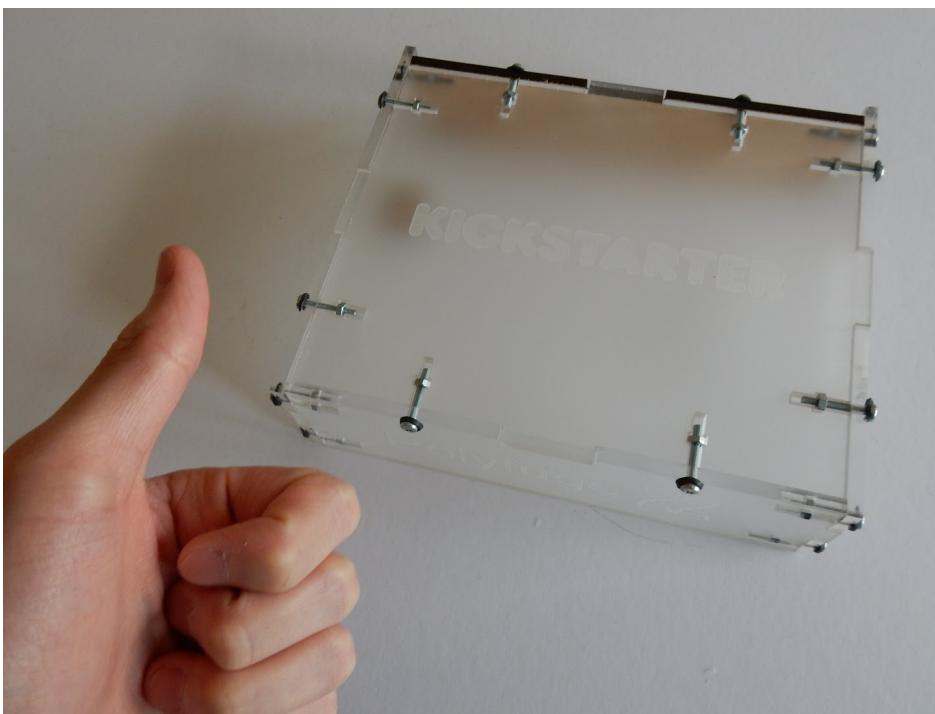
Secure the panels together using 20mm bolts, rubber washers, and nuts using the T-slots (same as we did for the base)!





32

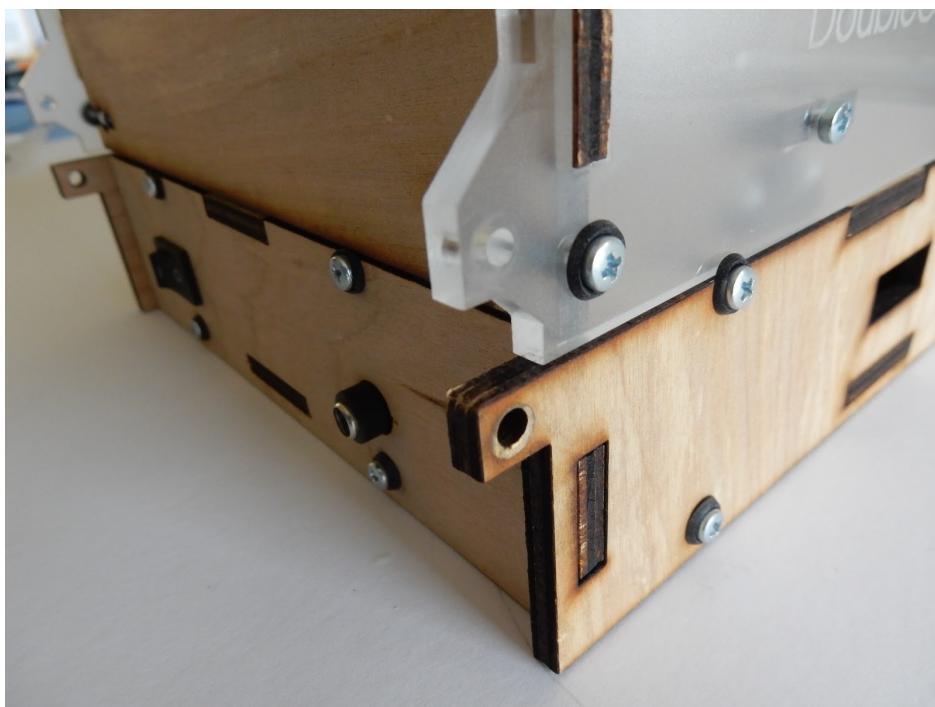
Great job - our lid is set! Take another break for getting through all of the difficult parts of the Polyfuge assembly process.



Connecting the Lid & Base

33

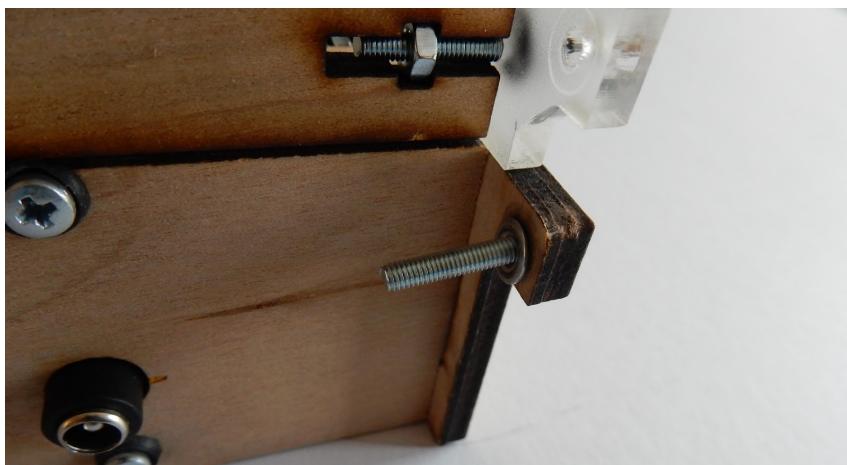
Locate the hinge pieces and turn the base towards you.

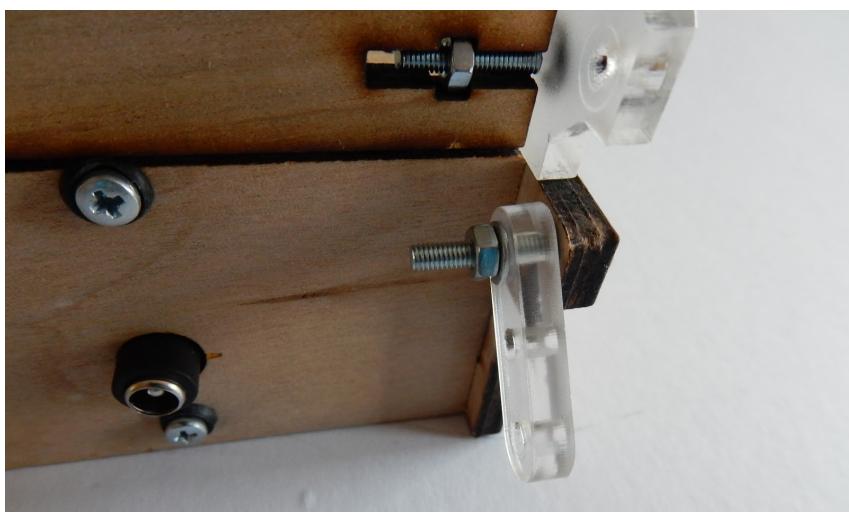
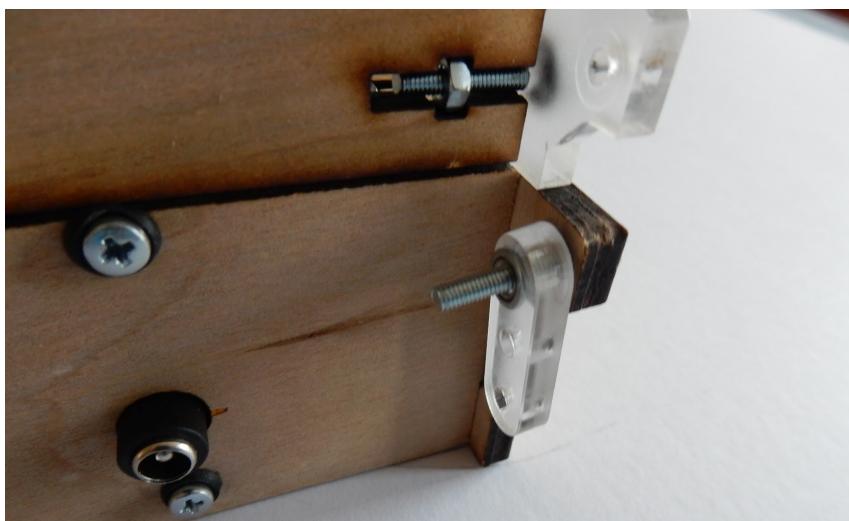
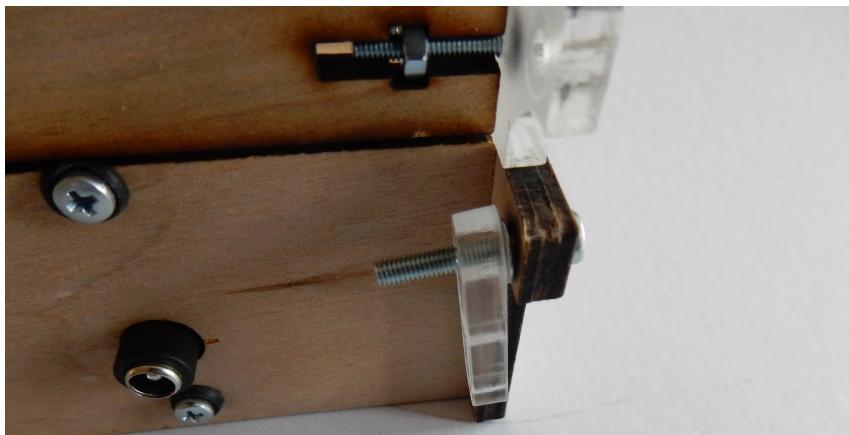


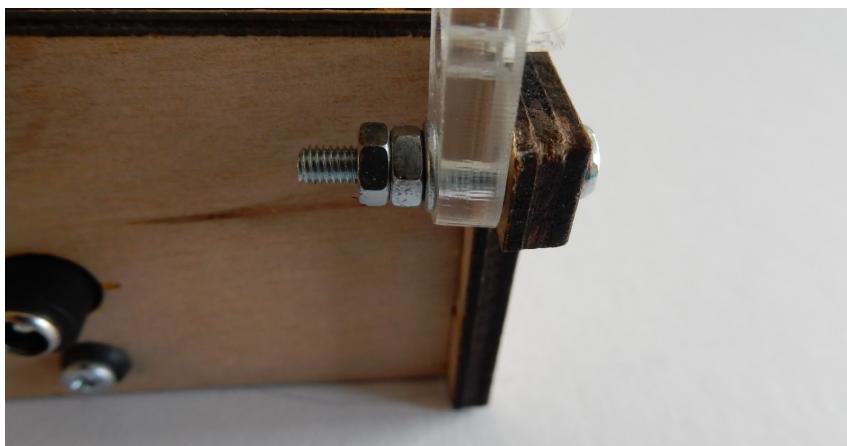
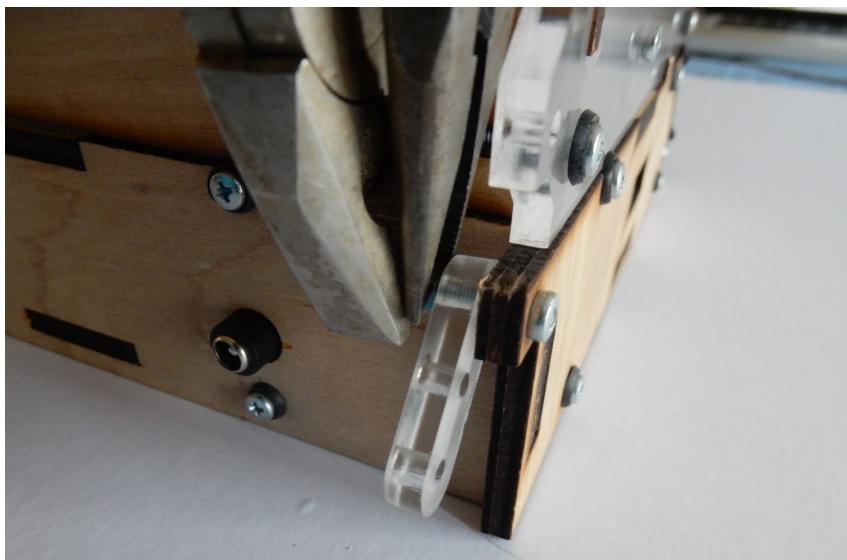
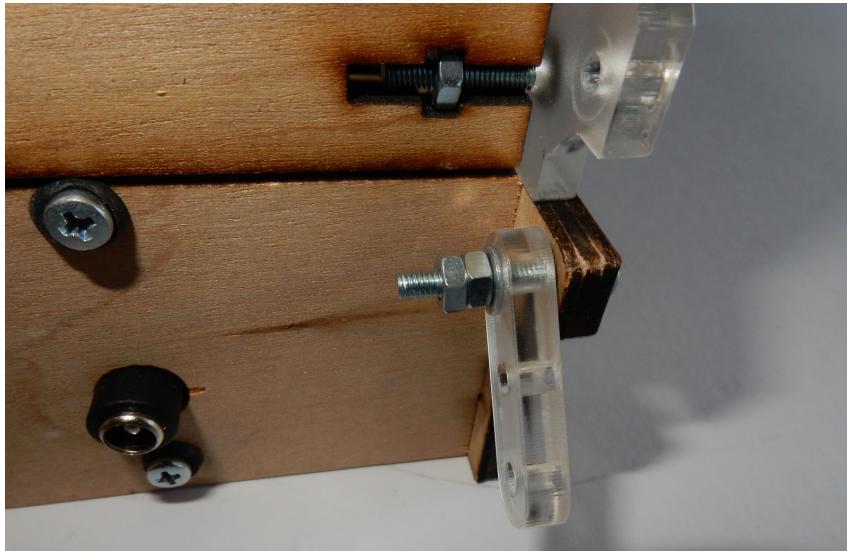


34

Connect the hinge piece to the base using a 20mm bolt, two washers, and two nuts in the following configuration:

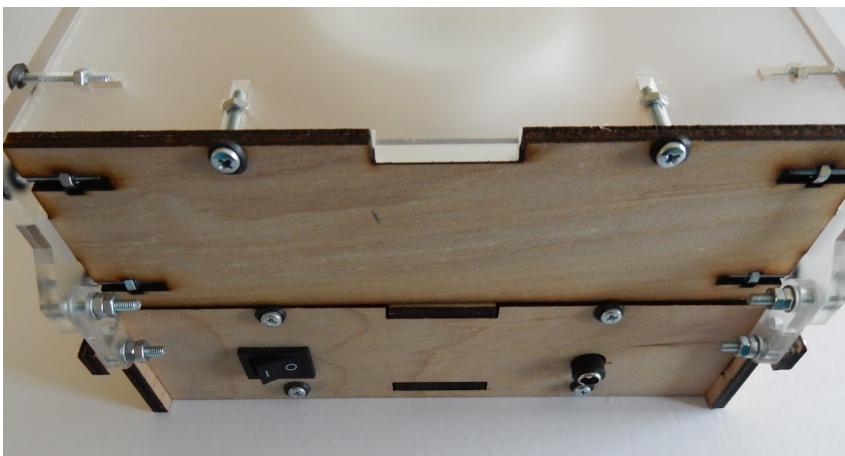
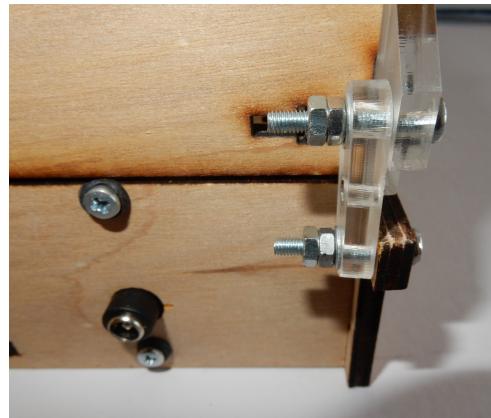
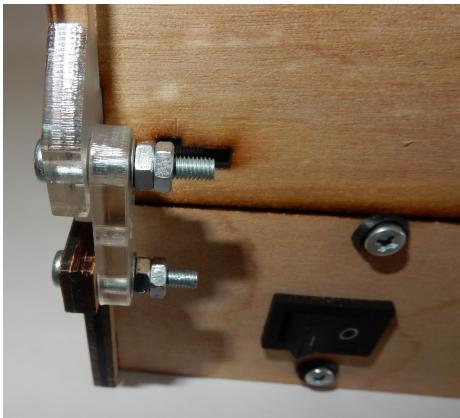






35

Repeat this process three more times to connect each hinge to the lid and the base.



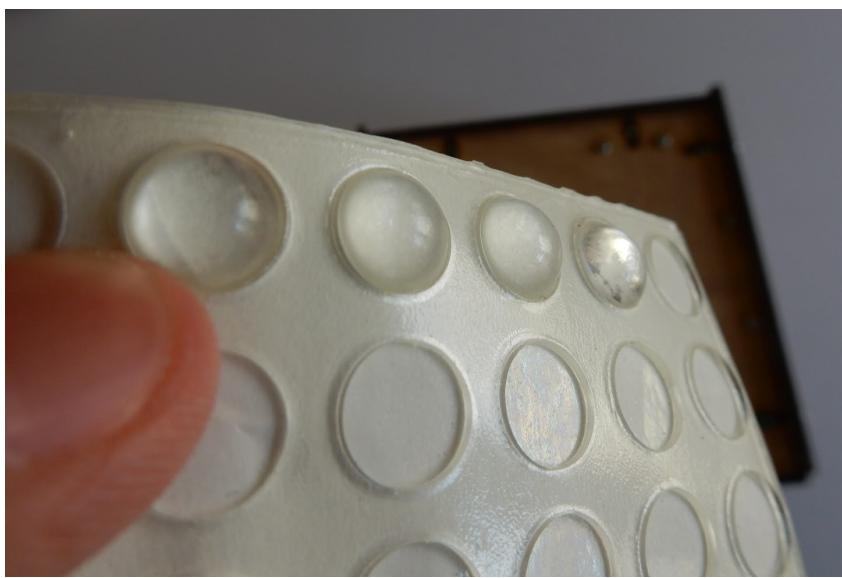
36

Finally, flip the unit over so the bottom of the unit is facing you.



37

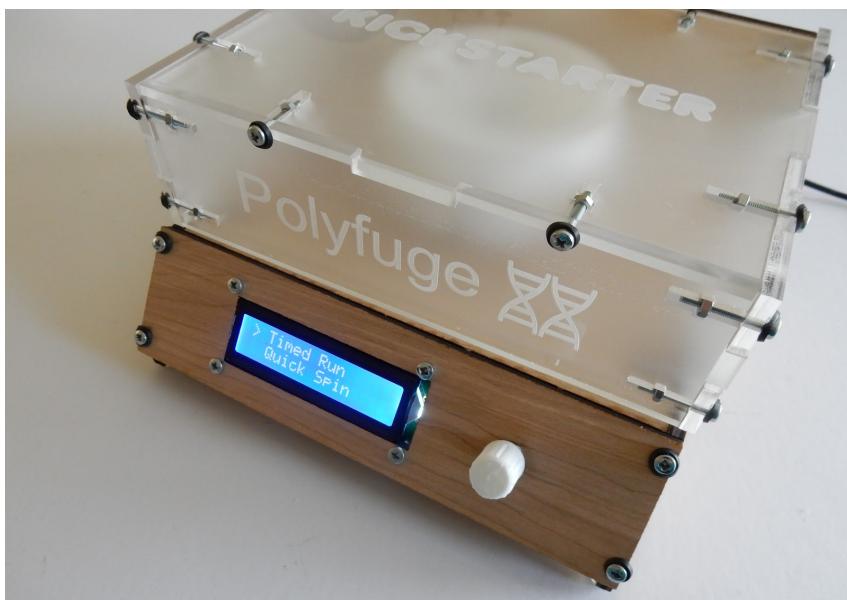
Place four hardware bumpers on each corner of the bottom.





38

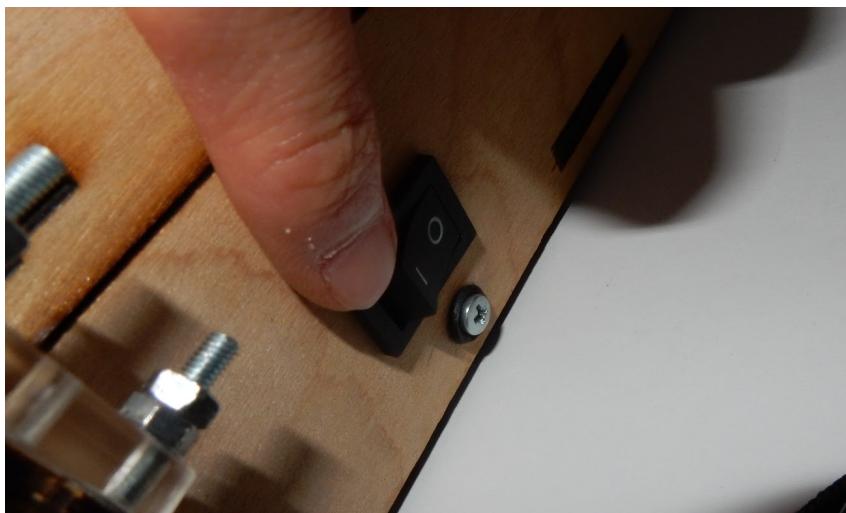
Congratulations! You have finished assembling Polyfuge - take a break, stretch your hands, and move on to our safety test!



Safety/Function Test Instructions

1

Plug in the unit and turn on the rocker switch on the back of the Polyfuge unit.



2

Wait through the loading screen - you should hear a short beeping sequence from the motor followed by a selection menu.



3

Twist the rotary encoder in both directions: moving the encoder clockwise should cause the selection indicator to move to the “Quick Spin” option, and counter-clockwise movement should cause the selection indicator to move to the “Timed Run” option.



3

Press the rotary encoder button on the “Timed Run” selection to set up a one minute spin.



4

Next, we encounter the speed select. Just stick with the lowest setting for now, since we're just running a safety test.



5

Time for the time selection! Twist the rotary encoder to set a run time of 1 minute and 0 seconds. Press the button when you're done!



6

Finally, you will be greeted with the confirmation screen - make sure the lid is closed and confirm the run by setting the rotary encoder to the “Yes” option and press the button.



7

Nice job - you just started your first Polyfuge run! You should see a countdown timer on the screen for the run time.



8

Allow the motor to run for around 20 seconds or so. During this time, you should hear no crashing sounds. In the event that the rotor sounds like it's breaking or hitting something, turn the device off and inspect the device immediately.

9

First, let's test the button safety cancellation! While the run is taking place, press the operation button. This should cancel the run and stop the motor.



10

All set? Awesome - now let's work on testing the lid safety function. Repeat steps 3-8 for another 1 minute timed spin.

11

Now, instead of pressing the button to cancel the run, try opening the lid (other than for this safety test, the lid should never be opened during a run)!



12

If the run properly terminated, you're all set!
Have fun running experiments!

Operation Instructions

Congratulations on assembling and running the safety test for your Polyfuge unit! Now, let's delve into how to use the device.

1

On the back of the device, you'll find a boat rocker switch that feeds power into the circuit. Make sure to flip it on before use, and to turn it off once you're done!



2

Place your tubes inside the rotor and make sure that the tube configuration is balanced or else serious damage may occur (see page 7). Shut the lid once the tubes are set in place.

3

Next, you will be greeted by a short opening sequence followed by a run selection screen.



4

There are currently two selectable spin modes within the Polyfuge software. **Timed Run** is for general centrifuging sessions, and runs the spin for a specified amount of time. **Quick Spin** is a ~1-2 second spin that is used for bringing liquids to the bottom of the tube.

For the timed run option, you will also be prompted to select an input time as well as a speed. “Microseconds” set the speed, and are values inputted to the ESC of the brushless motor. A higher microsecond count equates to a faster RPM.

5

When you need to cancel a run, press the rotary encoder button on the front of the device. **Do not open the lid to remove your tubes until the rotor completely stops moving.**

5

If your timed run finished, wait for the rotor to reach a complete stop. Next, open the lid and remove your tubes from the centrifuge rotor.



6

Start running some fun experiments!

Acknowledgements

Before we end this User's Guide, we would like to give a huge thank you to the folks at Chai Biotechnologies and OpenPCR who allowed us to use their format for this manual!

Furthermore, Polyfuge would not have been possible without the support of our 103 Kickstarter backers, who provided us with the funding needed to make our prototype a reality.

Thank you to everyone who helped us bring Polyfuge to communities around the world!

Keep on exploring biology!

Support Information

Have a question about hooking up electronics?

Want to learn more about the centrifugation process?

Got an idea for our next project?

Contact us at:

support@doublegene.com

DoubleGene
Princeton, New Jersey

