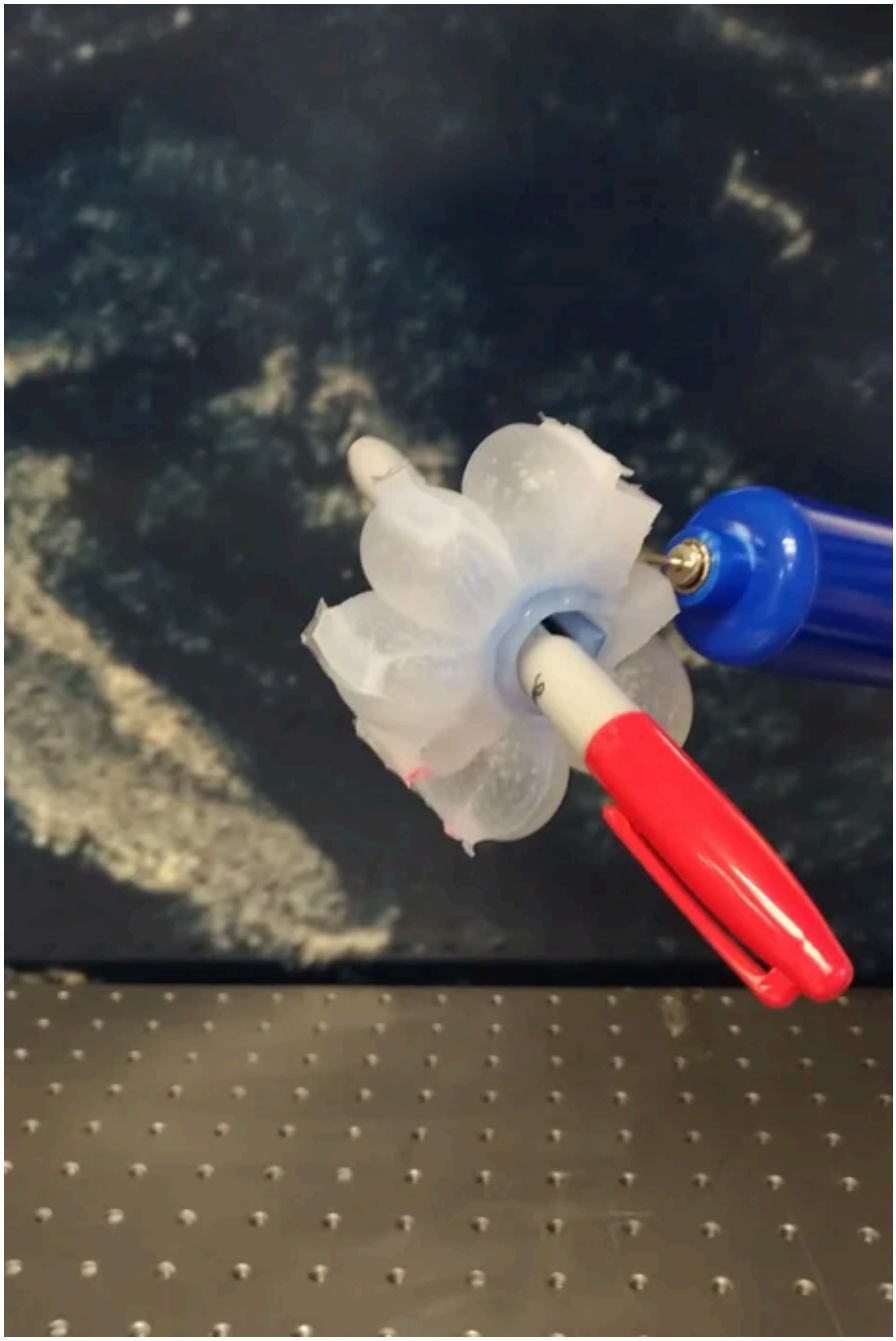
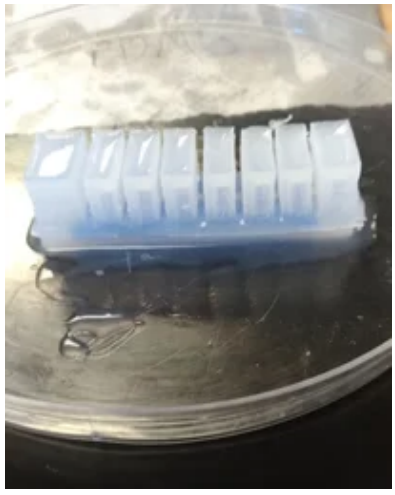
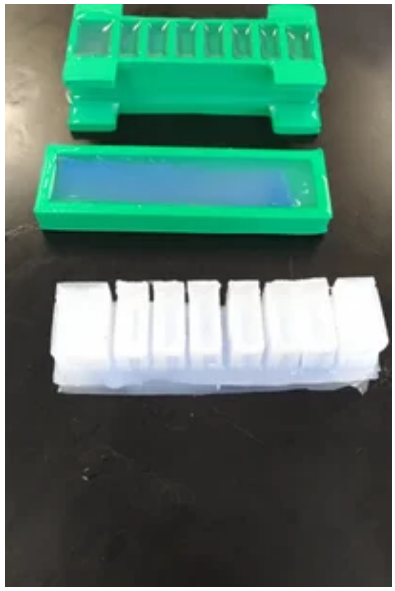
Soft Robotic Gripper

By jessica_ganley in CircuitsRobots

Introduction: Soft Robotic Gripper







The field of soft robotics (robots made from intrinsically soft materials such as silicons and rubbers) has been growing rapidly in recent years. Soft robots can be advantageous in comparison to their hard counterparts because they are flexible, adaptable to new environments, and they foster safer human-robot interaction. Soft robotic grippers, in particular, can be useful for handling delicate objects without causing damage.

This Instructable serves as a detailed guide on how to construct soft robotic "fingers" that can be easily operated with a simple hand pump. The STL files for the 3 piece mold can be found at the bottom of the page, in addition to the STL file for a central hub which will allow you to create a fully functioning 4-fingered soft robotic gripper. This project is ideal for soft robot enthusiasts and classrooms alike, with relatively few supplies needed and fast fabrication times.

The soft robot in this Instructable was inspired by the Whiteside's research group at Harvard and their work with creating pneumatic networks: https://gmwgroup.harvard.edu/soft-robotics. Inspiration was also drawn from the extensive resources at Soft Robotic Toolkit.

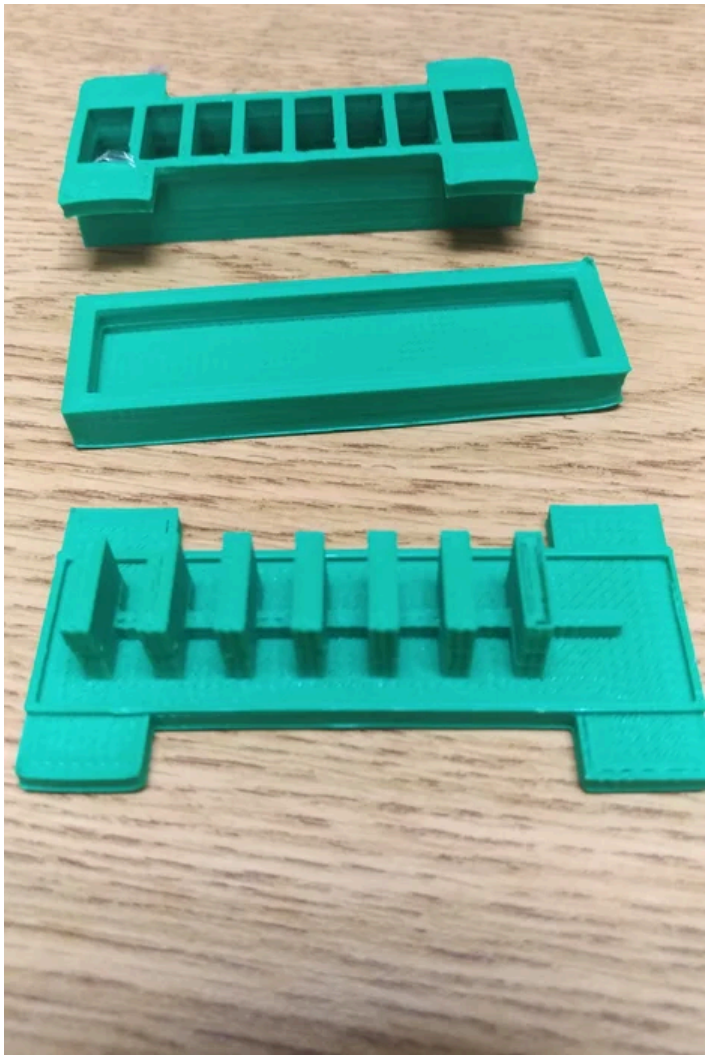
Supplies

- 3D printer (I used a LulzBot Taz 5, but any printer should work)
- PLA filament (ABS or any other filament type should work as well, just make sure it is compatible with Ecoflex 00-50)
- Trial size kit of Ecoflex 00-50. You can also use Ecoflex 00-30, but the 00-50 is more durable and preferred if possible
- Popsicle stick or coffee stirrer
- Container with volume marks to measure Ecoflex. Can also use a scale if you have access. You just need some way to measure parts A and B of the Ecoflex into a 1:1 ratio by mass or by volume.
- Cotton fabric (about 1 square foot will make several robots)
- Scissors
- Paper clip
- Ball pump

Optional extra materials (needed for full 4-fingered claw)

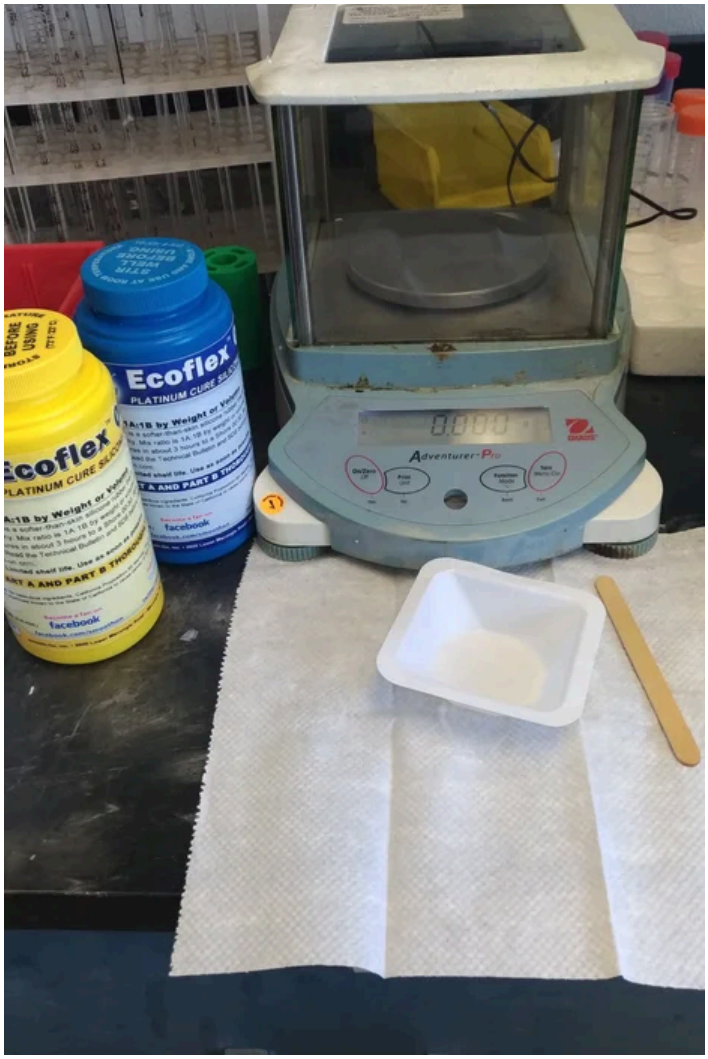
- Aquarium pump
- Plastic tubing (1/8 inch Outer Diameter) - about 2 feet will be plenty

Step 1: Print Your Mold



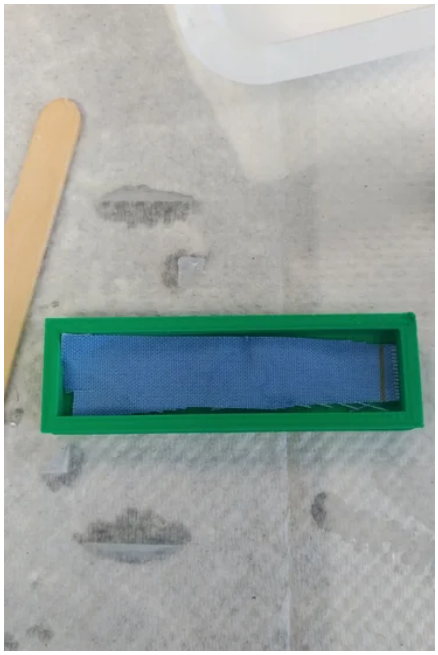
The first step is to print your mold. There are 3 pieces, 2 that fit together to make the top half and one for the bottom. I used PLA, but you can use ABS or any other filament. Just check that your material will be compatible with Ecoflex 00-50. Make sure to orient the parts so you don't need to generate support material.

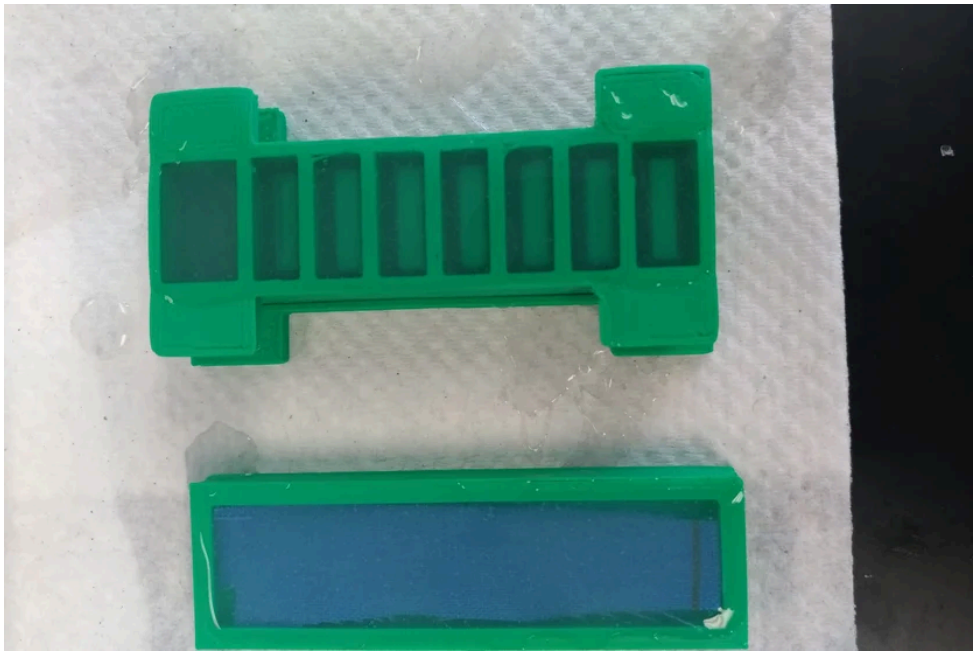
Step 2: Mix Your Ecoflex 00-50



The next step is to mix the Ecoflex 00-50. You could also use Ecoflex 00-30, but the 00-50 seems a little stronger and more ideal if possible. Be aware, the pot life (time the Ecoflex is flowy enough to work with) is only 18 minutes, so it may be a good idea to prepare the fabric and molds (refer to next step) before you start mixing. Ecoflex 00-50 comes in 2 parts (A and B) and is mixed in a 1:1 ratio by weight or by volume. Make sure to shake the bottles before pouring. You'll need approximately 8-10 grams of A and B (16-20 grams total) to fill one mold, top, and bottom. Once you pour A and B together, mix with a popsicle stick for 2-3 minutes. Mix well, but try to avoid mixing too vigorously (this will create unwanted bubbles that could harm the structural integrity of the robot).

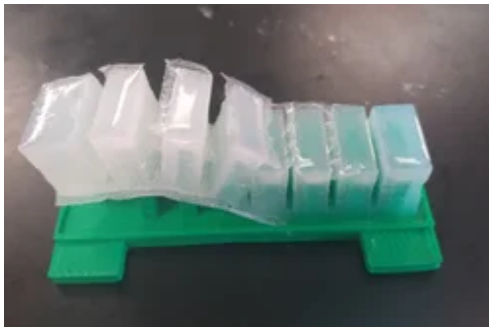
Step 3: Pour the Molds

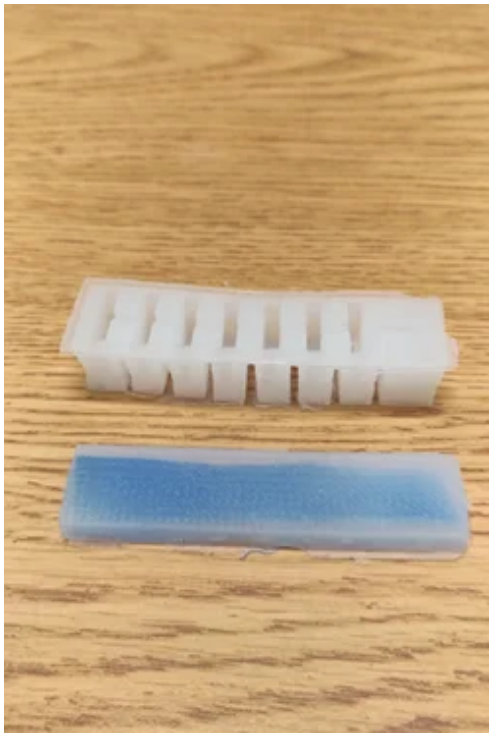




Cut a piece of fabric (or printer paper if you don't have access to fabric) that's slightly smaller than the bottom half of the mold. Place the 2 pieces of the top mold together (Note: one side of the top part of the mold has a slightly larger hole. This side goes over the empty area of the bottom part of the top mold. This will form the entry chamber which will not inflate, but will provide structural integrity). Slowly pour the Ecoflex into the bottom mold until it's about 1/2 full. Then place your fabric/paper into the bottom mold and fill it the rest of the way. Next, fill the top mold. Make sure each chamber appears completely full. Place on a flat surface and wait 3 hours for the Ecoflex to cure.

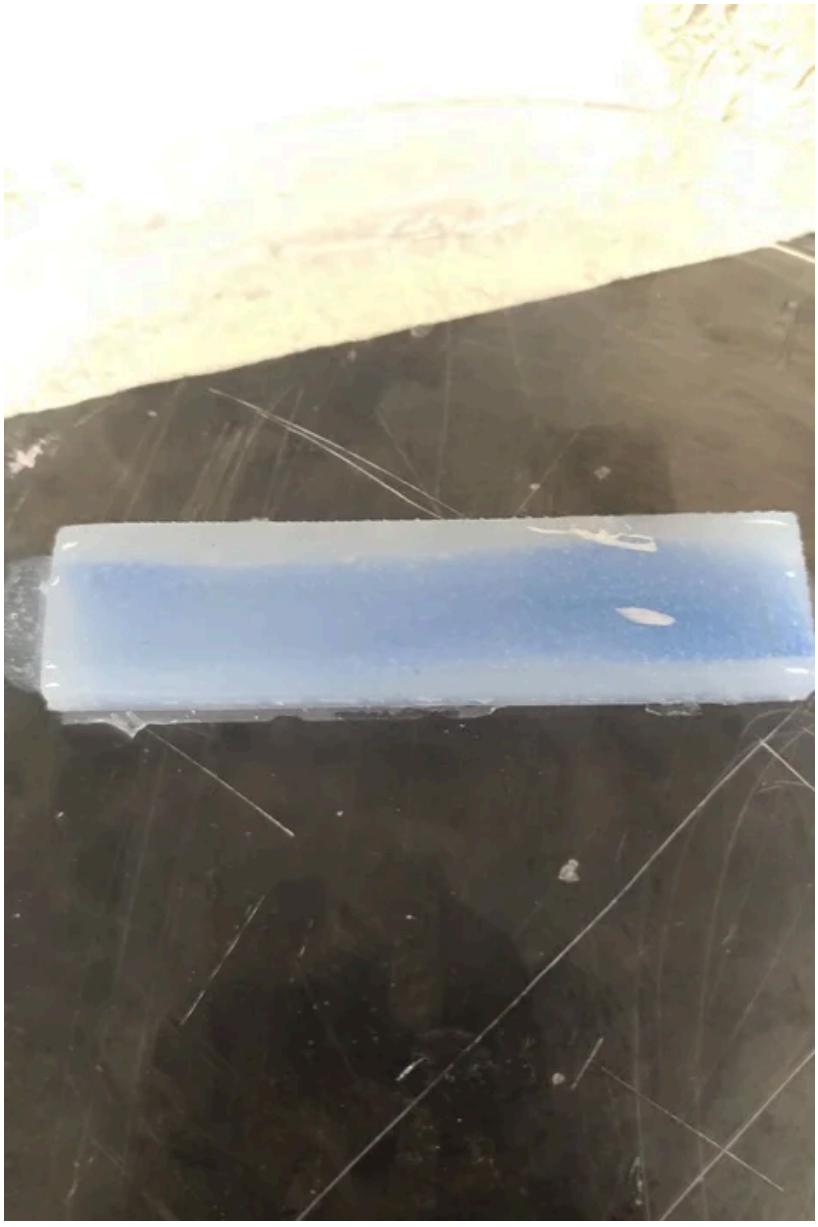
Step 4: Demold Both Halves

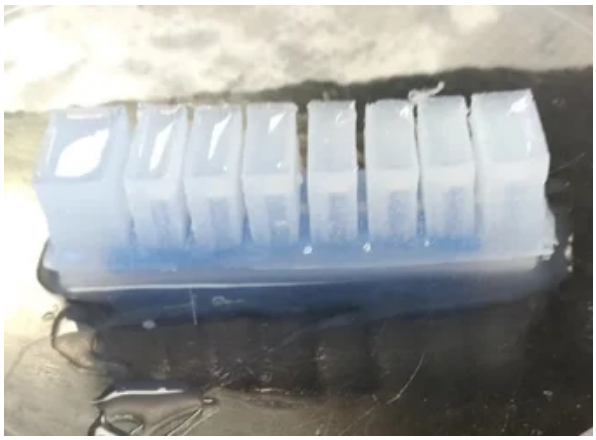




After 3 hours, it's time to demold! You can use tweezers to trace the edges of the molds which will make it easier to remove. The Ecoflex is stretchy so don't be afraid to pull on the mold, but be careful not to tear any of the thin areas. For the top mold, use the small rectangular holds to pry the sides apart.

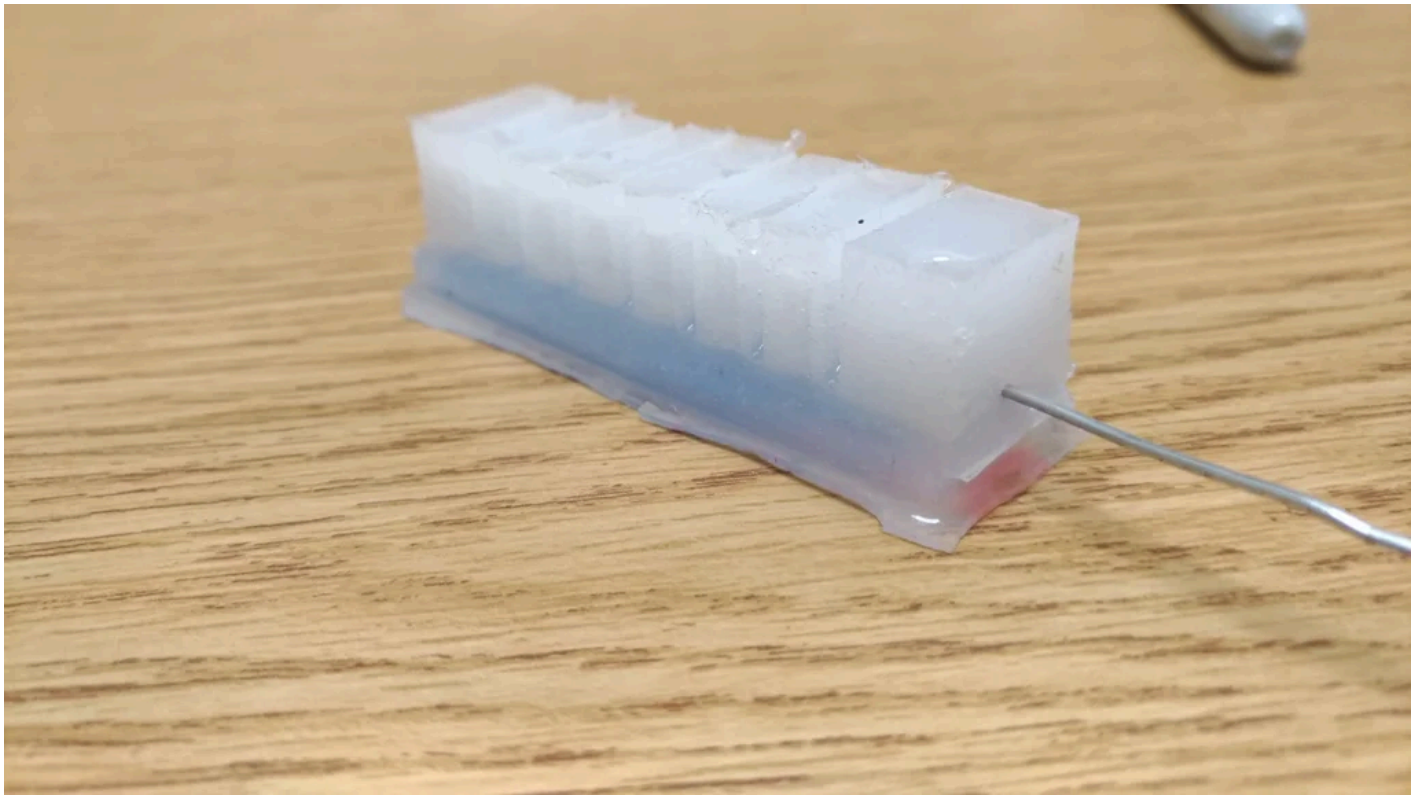
Step 5: Seal the Halves Together





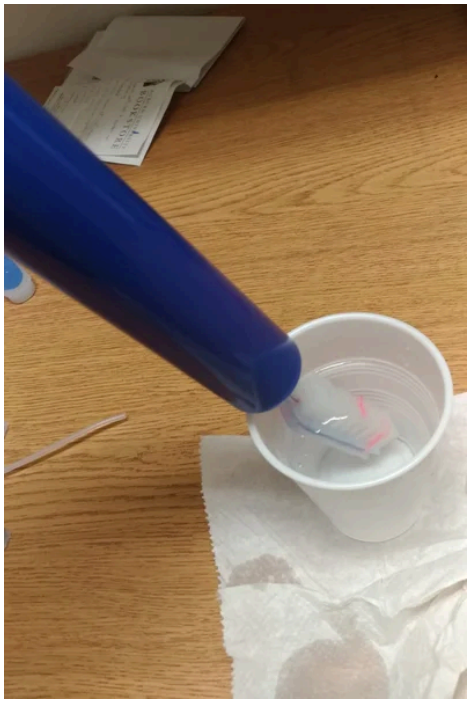
Now it's time to seal the halves together! Make a new batch of Ecoflex (this can be a very small batch) and spread a THIN layer on the bottom piece. Less is more here, you want to be sure to avoid clogging the air channel! Then, place the top half onto the bottom piece and use your popsicle stick to paint around the edge where the two pieces meet. Do this on parchment paper or tinfoil (not paper towel because the Ecoflex will cure to the paper towel). It is a good idea while doing this step to put some extra Ecoflex between the solid first chamber and the second chamber. This will reinforce this area to ensure it doesn't rip when you put your air source in. If some extra Ecoflex gets around the robot, don't worry- you can cut this off with scissors later on. Wait 3 hours and then remove the robot and cut off any excess Ecoflex.

Step 6: Puncture the Air Channel



Take the end of a paper clip and use it to puncture the air channel. Place it in the center, just above where the bottom piece meets the top piece. Make sure that you puncture the large chamber with no air pocket (not the other side which has an air pocket!). The air channel begins in the center of the first large chamber, so you don't need to press the paper clip in too far. Be careful not to press it in too far or you could accidentally rip the robot.

Step 7: Test! Seal Any Leaks If Necessary

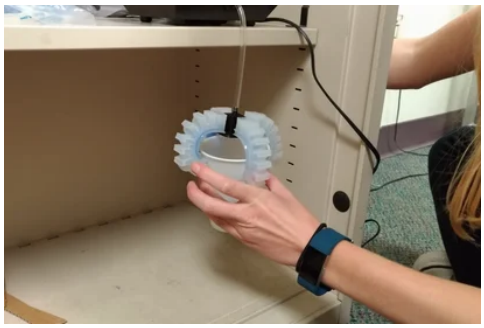




Now remove the paper clip and place the needle of your pump into the hole you just created with the paper clip. Pump and watch your robot inflate!

Troubleshooting:

- If you experience resistance when you try to inflate, you have not found the air channel, try to reposition the needle in the robot.
- If you hear air rushing out, your robot could have a hole. You can fill a cup with water and pump air into the robot to identify where the leak is (you'll see bubbles coming from the hole). You can mark the hole with a sharpie and make another batch of Ecoflex to seal the hole.
- If certain chambers don't expand, your air channel is clogged. You can try to use the paper clip to unclog it, but chances are you may have to remake the robot. No need to fear though- the mold is entirely reusable and you should have plenty of Ecoflex left over!

Step 8: Optional Extra Step: Create a Full Soft Robotic Claw!



Under the file section, there is an STL for a central hub. This can be 3D printed (it requires support so pay attention to what type of support you use to make sure it will come off without breaking the thin tubes) using PLA or any other filament. The central hub can be hooked up to tubing (1/8 inch outer diameter) and then to any air pump (I used an aquarium pump). Once you've printed the central hub, make 4 soft robot fingers and attach them to the 4 outer tubes. Attach the tubing to the large tube on top of the central hub, attach the pump to the other end of your tubing, turn your pump on, and watch your claw inflate!

Step 9: .STL Files

Here are the .STL files for the central hub and the 3-piece mold!