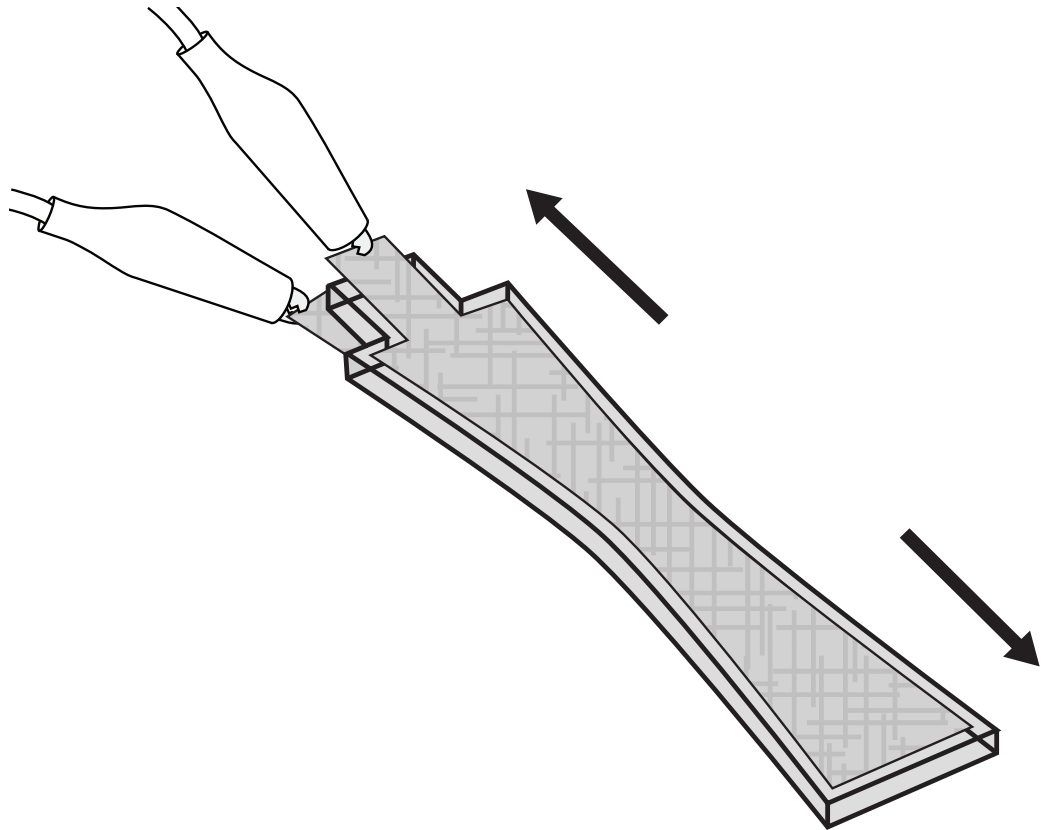


TEXTILE- SILICONE HYBRID SENSOR

An Educator's Guide

Soft Robotics Toolkit, 2017

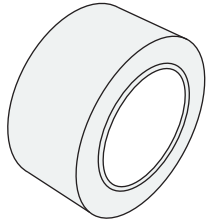
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SUPPLIES



RULER



CLEAR TAPE



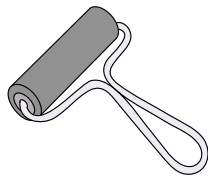
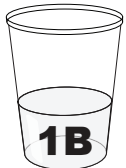
FABRIC SCISSORS



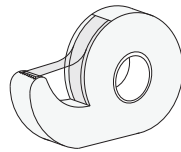
MIXING STICKS



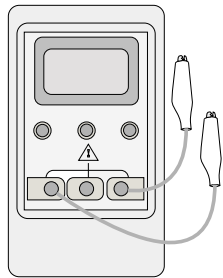
ECOFLEX 00-30



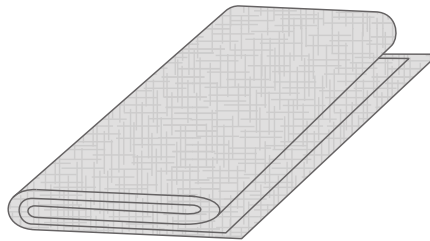
ROLLER



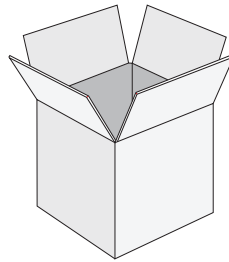
DOUBLE SIDED TAPE



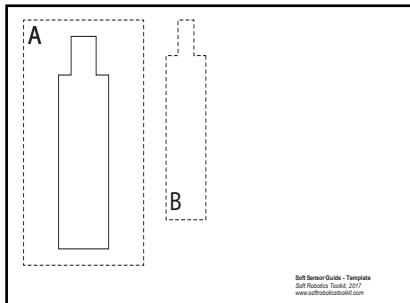
LCR METER



CONDUCTIVE FABRIC (P1)



CARDBOARD (P2)



TEMPLATE



CARDSTOCK (P3)



BOX CUTTER

A more detailed supply list for this activity is located in the Bill of Materials document that was within the fabrication guide package. Please be advised that if the supply list calls for box cutters, irons or scissors it is under the discretion of the educator to decide if their group is able to use these tools as part of the activity or substitute as needed.

Ruler: Provides a guide for students using a box cutter to cut the template.

Clear Tape: For laminating the cardboard and templates to protect the silicone from leaking through.

Scissors: To cut the paper templates and the fabric. Should be sharp enough to cut knit fabric.

Mixing Sticks: Used to mix the two parts of the elastomer together.

EcoFlex 00-30: Elastomer used for the middle layers and as adhesive layers for the fabric.

Roller: Also sometimes called a brayer, this allows the layers of the sensor to be firmly adhered.

Double-Sided Tape: Connects the cardstock and cardboard layers of the mold.

LCR Meter: Meter for testing the capacitance of the sensor.

Conductive Fabric: Creates the electrode layers on either side of the sensor. Referred to as P1 in the guide.

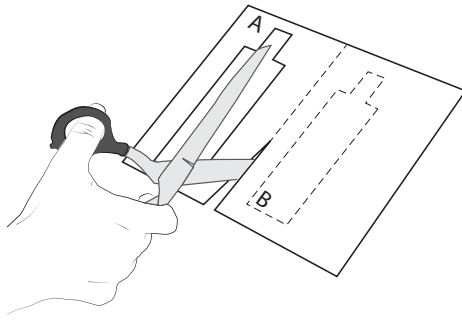
Cardboard: Creates the mold for the inner layer of the sensor. Referred to as P2 in the guide.

Template: Outlines the pieces for the base and the middle portion of the mold.

Cardstock: For template B of the sensor. Referred to as P3 in the guide.

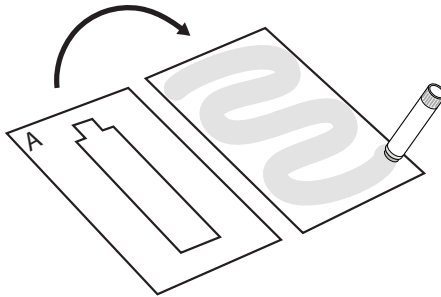
Box Cutter: For cutting the cardboard and cardstock templates.

01



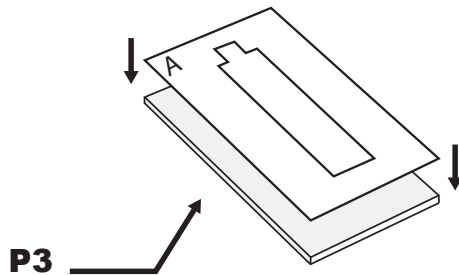
Cut along the dotted line to separate template A from template B.

02



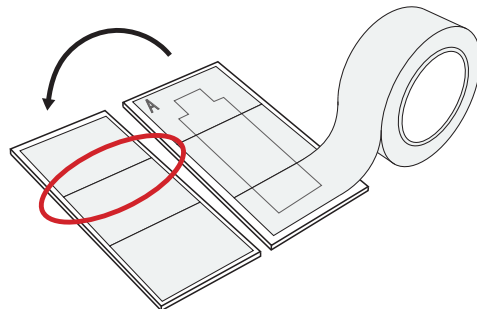
Using paste glue, spread a layer across the entire back of template A making sure to cover the entire surface evenly.

03



Paste template A onto cardstock (P3).

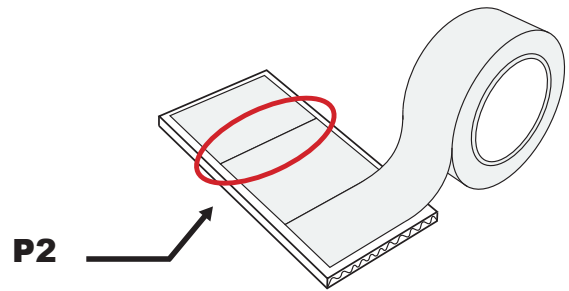
04



Use the clear packing tape to laminate both the front and back sides of the cardstock.

NOTE: Ensure that there are no gaps between the pieces of tape, students may overlap the edges of the tape to ensure that it is properly laminated. The cardstock must be completely sealed to prevent leaking of the EcoFlex in later steps.

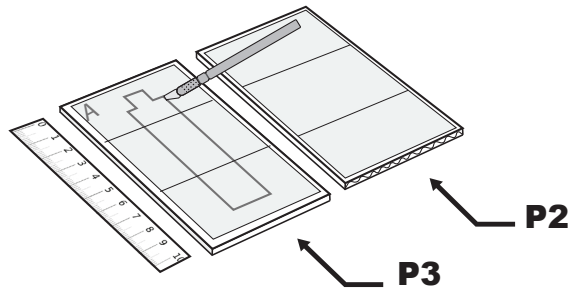
05



Cut a piece of cardboard with a box cutter that is the same size as template A. Use the clear packing tape to laminate just one side of the cardboard. This will serve as a tray for the sensor to be poured onto.

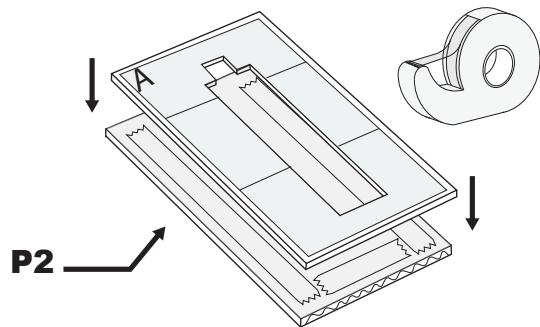
NOTE: Overlap the edges of the tape to ensure that there are no gaps between the pieces of tape. Like the cardstock, the cardboard must be completely sealed to prevent leaking of the EcoFlex in later steps.

06



Use the box cutter to cut along the solid line in the middle of template A to create a sensor-shaped hole. Remove both the paper and the cardstock within this outline. This will be the cavity of the mold.

07



The cardstock template must be placed onto the cardboard tray. Use double sided tape to secure the cardstock on top of the laminated side of the cardboard to complete the mold.

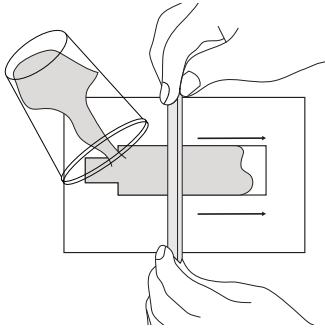
NOTE: Lay the tape on the underside of the cardstock as close to the inner edges of the cutout to minimize leakage of EcoFlex 00-30 between the two layers.

08 **EcoFlex 00-30**
1A:1B
10g:10g



Using a mass scale, measure out a 1:1 ratio of parts A and B of EcoFlex 00-30. 10 g of part A and 10 g of part B is recommended. Mix the silicone completely with mixing sticks for 30 seconds, or until completely mixed.

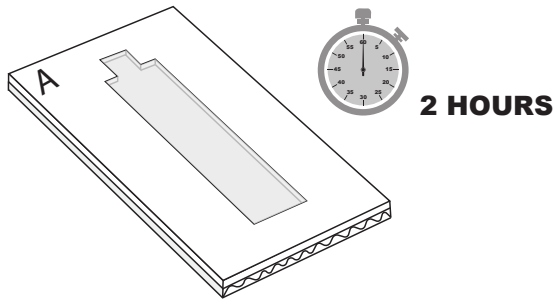
09



Pour the silicone into the mold, filling the cavity completely and evenly.

NOTE: The cavity is very shallow and fills up quickly. Have students pour their silicone slowly with the mold at eye level. If students overfill, they can use the side of a mixing stick to skim across the top of the mold, removing excess and spreading the silicone as evenly as possible within the cavity. Make sure to fill all of the corners evenly.

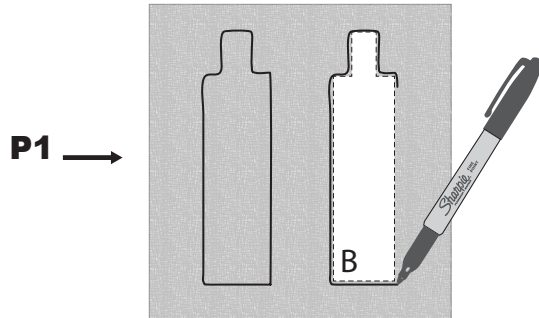
10



Let the silicone cure for 2 hours in the open air.

NOTE: If you have access to an oven, you can cure the silicone much more quickly. Turn the oven to 70°C (140°F) and let it cure for 20 minutes.

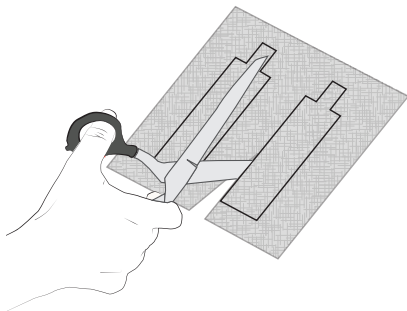
11



If not already cut out, cut the second template around the dotted line to reveal template B. This will be the fabric template. Trace template B onto the conductive fabric with a permanent marker. After tracing, place the template within the same orientation as the first and trace a second time.

NOTE: It is essential to copy the same template orientation such as in the illustration. The pieces must be cut so that the fabric direction is identical. Aligning the direction will ensure that the fabric will be able to stretch evenly and will have less interference measured when using the LCR meter.

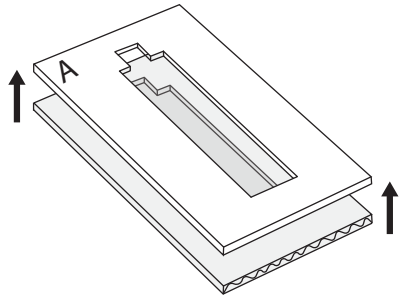
12



Once traced, cut out the fabric pieces.

NOTE: Have students use sharp scissor to cut the pieces out of the fabric as neatly as possible. This will prevent escaping fibers from causing short circuits when connecting the sensor to the LCR meter.

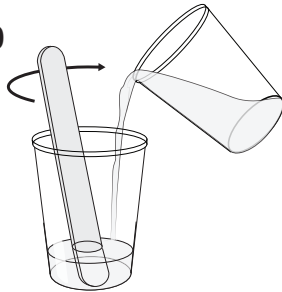
13



Touch the silicone with a finger to test whether or not it has cured completely. If the silicone still feels “greasy” or “tacky”, let it cure longer. If it feels “rubbery”, then the silicone is ready and you can peel the cardstock off of the cardboard, revealing the silicone sensor.

NOTE: Silicone might leak between the cardstock and cardboard, altering the sensor’s shape slightly. Students can trim their sensor back to shape using a box cutter or scissors.

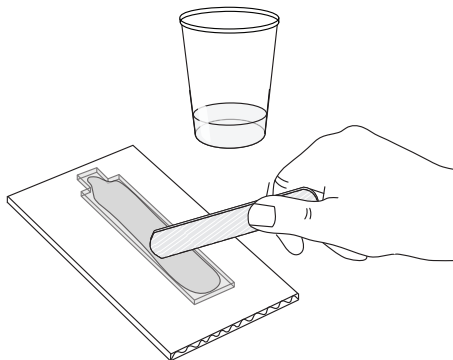
14 **EcoFlex 00-30**
1A:1B
5g:5g



Using a mass scale, measure out a 1:1 ratio of parts A and B of EcoFlex 00-30. 5 g of part A and 5 g of part B is recommended. Mix the silicone completely with mixing sticks for 30 seconds, or until completely mixed.

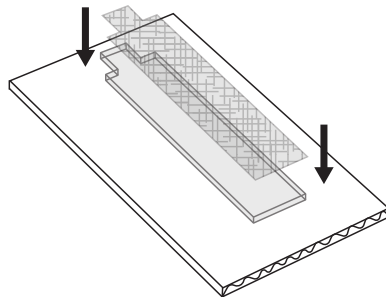
NOTE: If you have left over EcoFlex 00-30 from step 09 that has not cured, you may use that here instead of mixing a new batch.

15



Spread a thin layer of EcoFlex 00-30 on top of the cured silicone sensor using a small amount applied with a mixing stick. This will act as an adhesive for the fabric pieces so an even distribution of elastomer is needed.

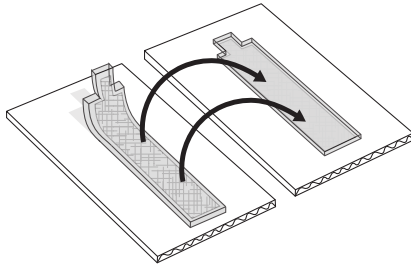
16



The conductive fabric will have a “shiny” side and a side that is more dull or brown hued. It is essential that the fabric pieces on either side have “shiny” sides facing away from the interior. Identify the “shiny” side of the fabric and align this side face-up (away from the silicone sensor body) and press into place in the center of the silicone.

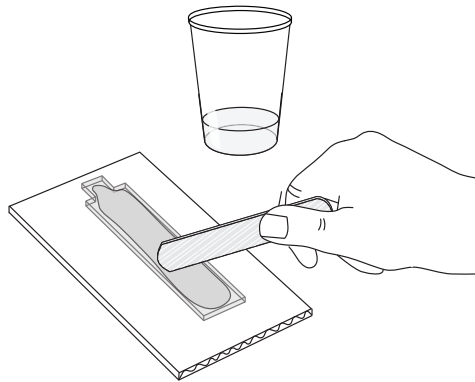
NOTE: Lay the fabric as straight as possible, and retry if you need to. Any folds in the fabric will cause an inaccurate reading on the LCR meter.

17



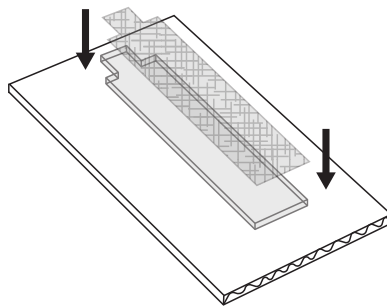
Before curing, flip the sensor over by peeling the sensor carefully from the tray and flipping it to face the fabric side down.

18



In the same technique as step 15, spread a thin layer of EcoFlex 00-30 on top of the cured silicone sensor. This will act as an adhesive for the fabric pieces.

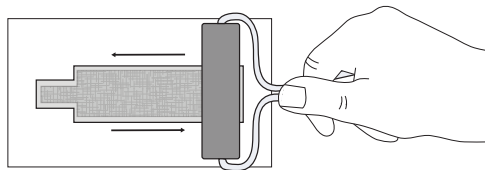
19



Identify the “shiny” side of the fabric. Align the fabric “shiny” side face-up over the silicone and press into place. The assembly of the sensor is complete. The fabric pieces should sandwich the silicone interior.

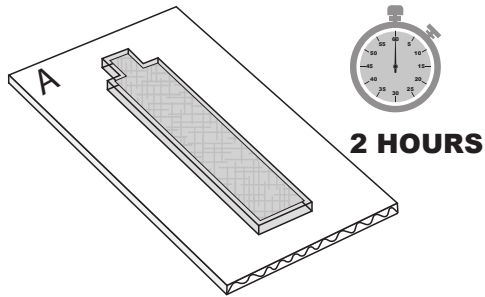
NOTE: Ensure that the “shiny” sides of the fabric pieces face out on either side of the silicone interior.

20



Lightly roll the roller forward and backward over both sides of the sensor. This will help the silicone adhesive layers to seep through the fabric, solidifying the assembly. Keep the sensor on the cardboard tray when finished rolling.

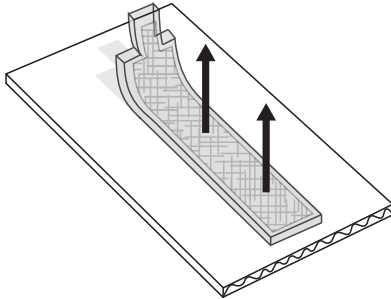
21



Let the silicone cure for 2 hours in the open air.

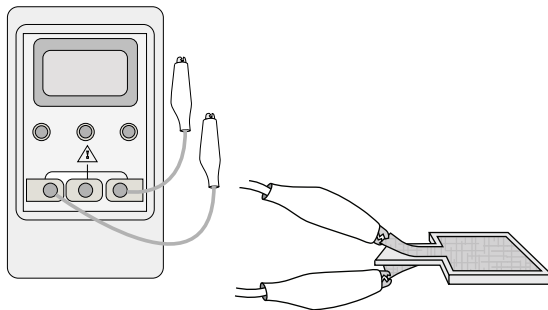
NOTE: If you have access to an oven, you can cure the silicone much more quickly. Turn the oven to 70°C (140°F) and let it cure for 20 minutes.

22



Touch the silicone with a finger to test whether or not it has cured completely. If the silicone still feels “greasy” or “tacky”, continue to let it sit longer. If it feels “rubbery”, then the sensor is complete.

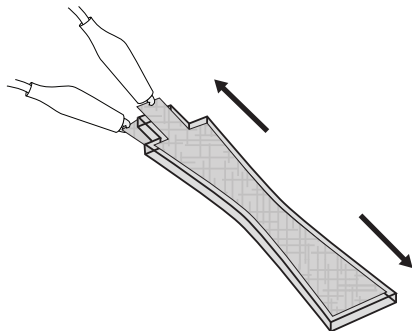
24



Peel the small ends of the fabric at the top of the sensor from the silicone just enough to attach an LCR meter lead. Attach one lead to each side of the sensor, clipping only onto the fabric itself. Plug the leads into the corresponding outlets on the LCR meter itself. Turn the LCR meter on and allow the meter to calibrate the sensor before stretching to test.

NOTE: Allow the LCR meter to calibrate and wait to let the sensor reading stop fluctuating before use.

25



You now have a complete soft sensor system. Have students stretch their sensors as far as they will stretch without ripping to observe how their capacitance rises and falls on the LCR meter.