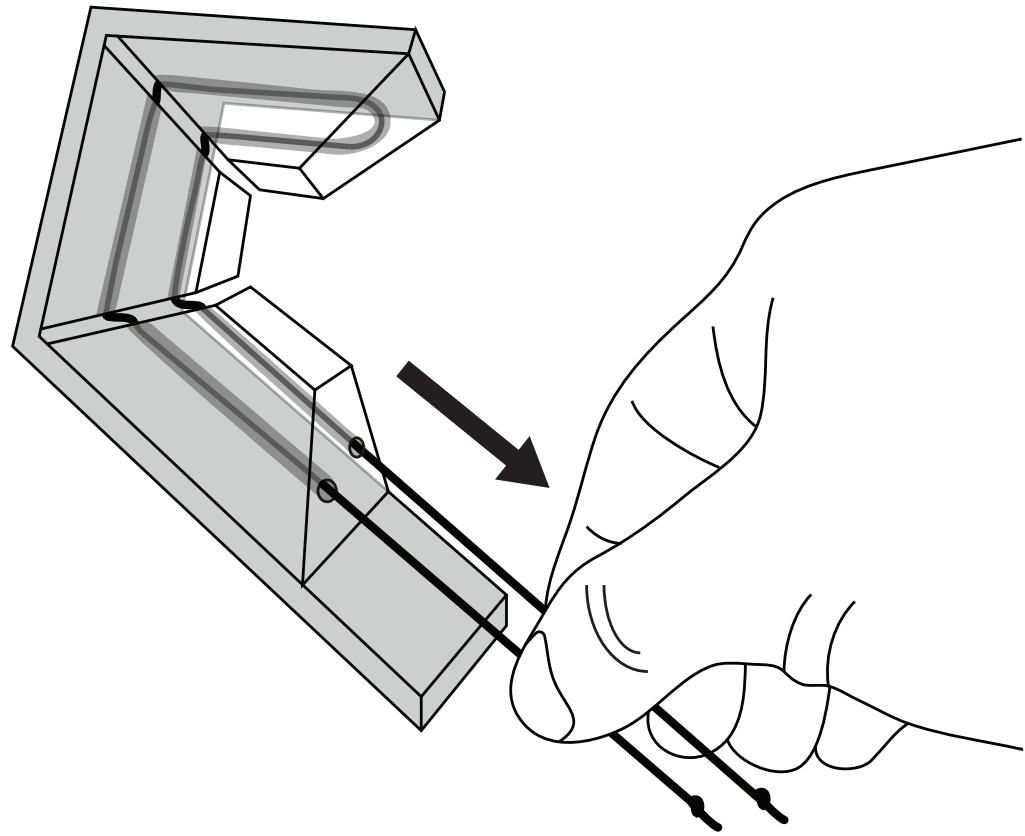


# SDM FINGER

**An Educator's Guide**

*Soft Robotics Toolkit, 2017*

[www.softroboticstoolkit.com](http://www.softroboticstoolkit.com)



# VOCABULARY

The following vocabulary can be utilized as an introduction into some of the terms used within our guides as well as within the larger field.

**Soft Robotics:** Soft robotics is a subfield of robotics that focuses on the research and design of soft and deformable robots. Organic motions and the soft bodies of animals and humans, are difficult to replicate with rigid robotic components. By exploring soft robots, scientists, designers and engineers work to create robots out of flexible and gentle materials like silicone rubbers, fabric, and other soft materials.

Applications for soft robots include but are not limited to delicate manufacturing, surgical soft robots, deep sea sample collection devices, soft and safe robotic grippers, prosthetics, and more!

**Gripper:** A gripper is the part of the robot that acts like a hand. It enables holding or moving an object and is usually customized to a desired application.

**Silicone:** Silicones are two part mixtures of rubbers. When both parts are combined it triggers a chemical reaction that causes the silicone to harden, or cure.

**Cure:** Curing describes the action of the silicone as it hardens. When the chemical reaction between the two parts is finished, the silicone the resulting rubber is cured.

**Mold:** A mold is like an ice-cube tray or a cake pan. When silicone is poured into a mold it cures and takes on the shape of whatever vessel it was poured into. Similar to freezing water in a dish or pouring batter into a cake pan, the silicone will flow to fill the vessel completely and will to retain this shape once it is hardened and removed.

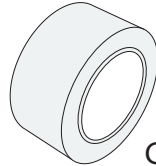
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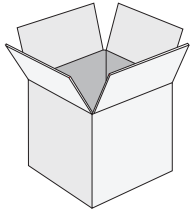
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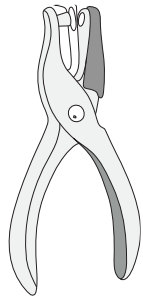
GLUE GUN



CLEAR TAPE



CARDBOARD



HOLE PUNCH



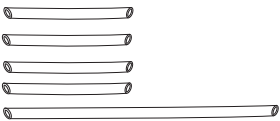
RULER



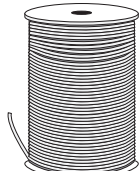
BOX CUTTER



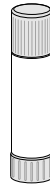
MIXING STICK



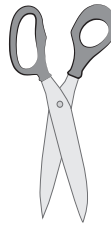
TUBING



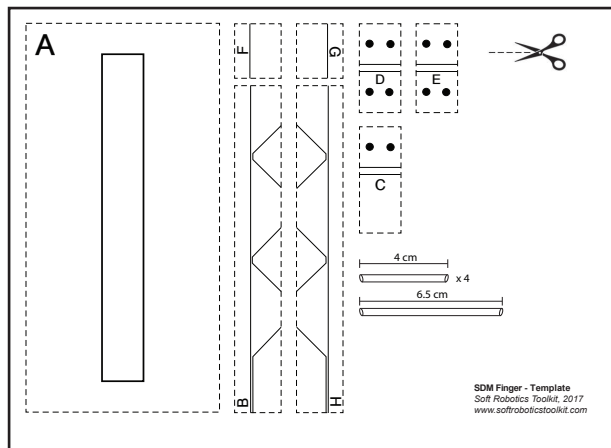
KEVLAR



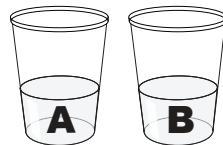
PASTE GLUE



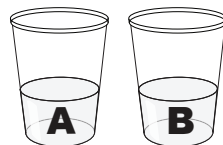
SCISSORS



SDM Finger - Template  
Soft Robotics Toolkit, 2017  
www.softroboticstoolkit.com



DRAGON SKIN 30



SMOOTH SIL 950

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.

**Glue Sticks:** 2-3 per mold is recommended.

**Glue Gun:** Helps to assemble and seal the cardboard mold.

**Clear Tape:** Used to seal the inside of the mold from the elastomer. For best results use clear packing tape.

**Cardboard:** For constructing the mold. You may use any recycled cardboard for this.

**Mixing Stick:** For mixing the two part silicone together.

**Ruler:** Helps to guide students using box cutters when cutting template pieces.

**Box Cutter:** For cutting the cardboard pieces for mold construction.

**Tubing:** Allows a channel for the kevlar to be established when molding.

**Kevlar:** Kevlar cord to control the movement of the finger.

**Paste Glue:** Glue to allow the paper templates to be pasted onto the cardboard.

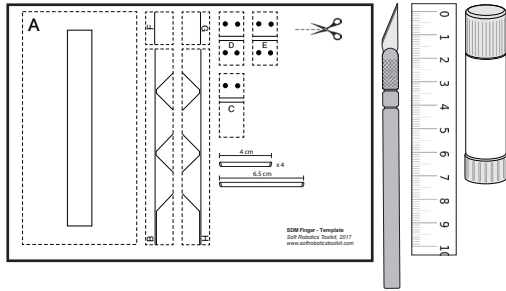
**Scissors:** For cutting the paper template, tubing and kevlar cords.

**Template:** Includes parts for the walls of the mold, the interior sections and the sizes of tubing needed.

**Dragon Skin 30:** For casting the first portion of the finger's construction.

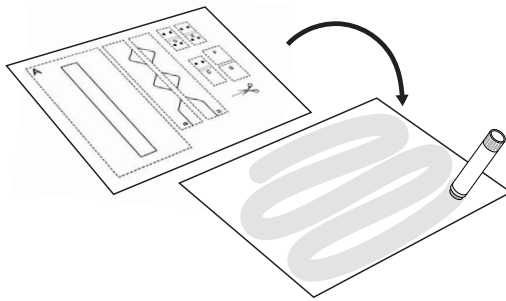
**Smooth-Sil 950:** For casting the second portion of the finger's construction.

01



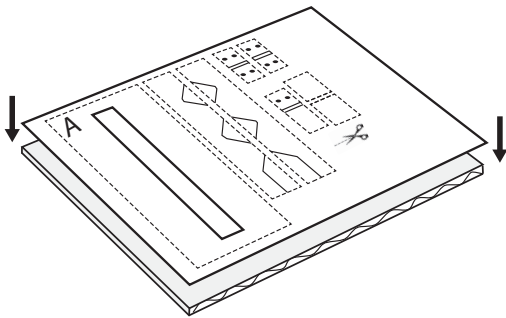
Gather the paper template, a box cutter, ruler and paste glue for the construction of the mold.

02



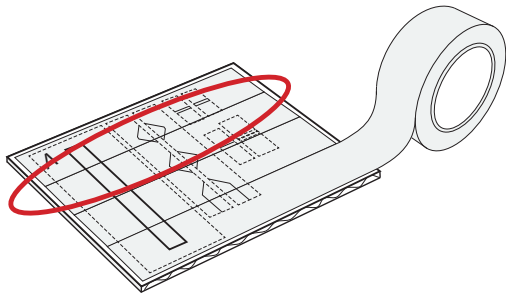
Spread paste glue across the back of the entire template.

03



Paste the template onto a piece of cardboard large enough to fit the whole template.

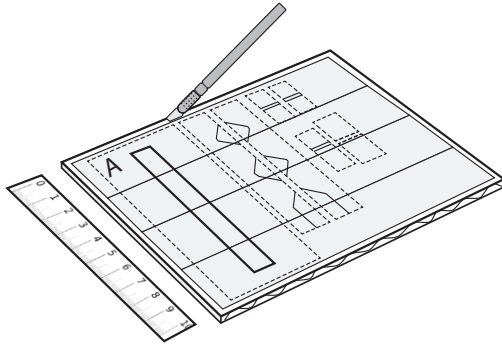
04



Use the clear packing tape to laminate the entire front side of the template.

**NOTE:** Overlap the edges of the tape to ensure that there are no gaps between the lengths of tape. The cardboard must be completely sealed to prevent the leaking of the Ecoflex in later steps.

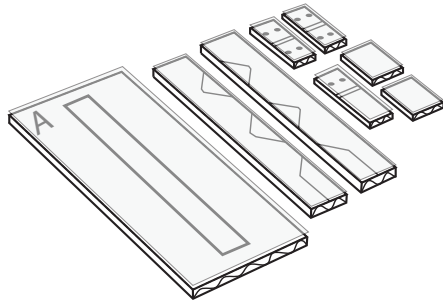
05



Use an box cutter to cut along the dotted lines, separating parts A-F.

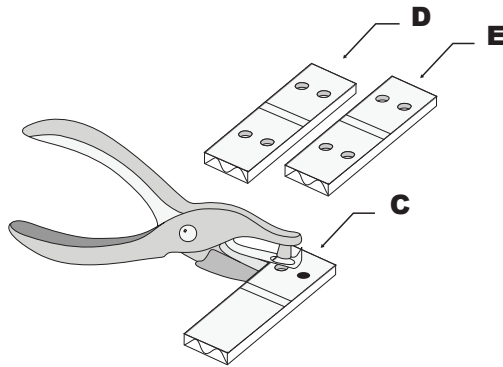
**NOTE:** Students may need close supervision at this step. Some students may struggle to use the box cutter, in which case they may use scissors. You can also score the template for the student to make it easier for them to cut.

06



Students should have parts A-F as individual pieces. A is the base with an outline for the finger mold. B and H are the long sides of the mold. F and G are the short sides of the mold. C, D and E are the sections added within the mold to shape the finger.

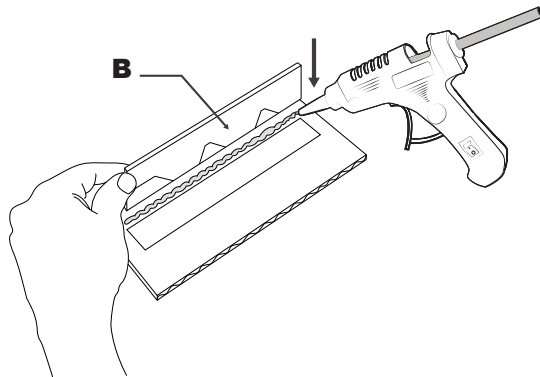
07



Use a hole puncher to punch holes through the black circles on parts C, D, and E. Tubing will run through these holes to provide a channel for the cord.

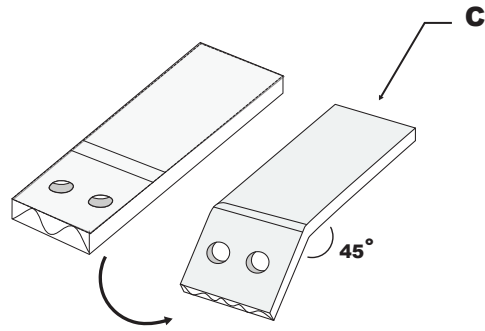
**NOTE:** Have students punch these holes carefully and accurately. When these pieces are folded up in the mold, the holes need to align as closely as possible.

08



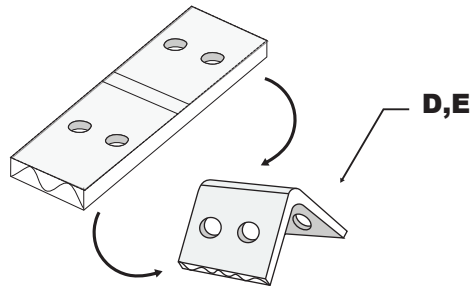
Use a hot glue gun to assemble part B onto the mold outline of part A. Ensure that the laminated side of B is facing the interior of the mold to protect the mold from silicone. "B" should be right side up. You will later assemble parts C, D and E inside the mold, using the solid lines on piece B as a guide.

**09**



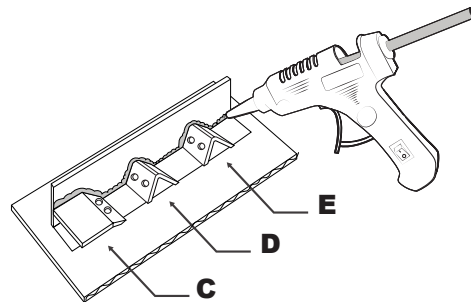
Fold part C along the lines printed to a 45° angle. The fold should be bent towards the non-laminated side of these pieces.

**10**



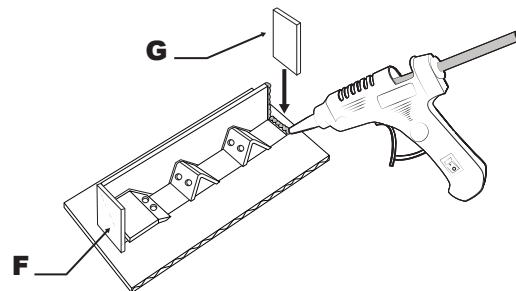
Fold parts D and E in half along their lines. The laminated side should be on the outside of the fold.

**11**



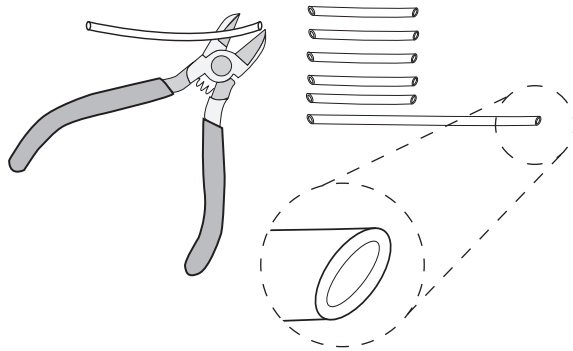
Use a hot glue gun to assemble parts C, D and E onto the mold outline of part A. Align C, D and E along the solid lines on part B. Secure the pieces in place by outlining the entire structure in hot glue. Make sure to line all of the areas where the parts meet, both inside and outside of the mold.

**12**



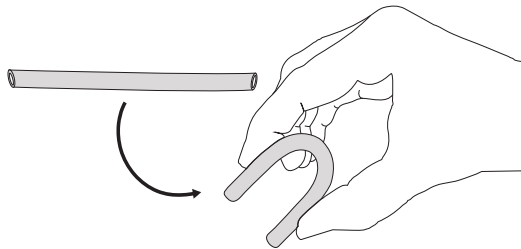
Use a hot glue gun to assemble parts F and G onto the short ends of the finger outline on part A. Ensure that the laminated sides are facing the interior of the finger mold to protect the mold from silicone. "F" and "G" should also be facing right side up.

13



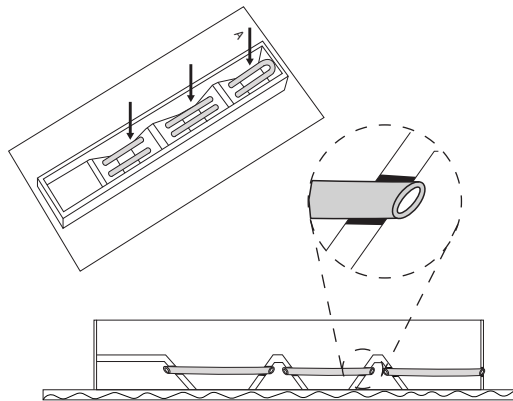
Use wire-cutters to cut 5 pieces of plastic tubing. 4 of the pieces should be 4 cm in length and 1 piece should be 6.5 cm in length. Refer to the template for a guide on tube lengths.

14



Bend the 6.5 cm tube in half but DO NOT crease it. The tubing will act as a guide later for the Kevlar cord. If students crease the tubing, the Kevlar will get stuck and will not be able to make it all the way through the tube.

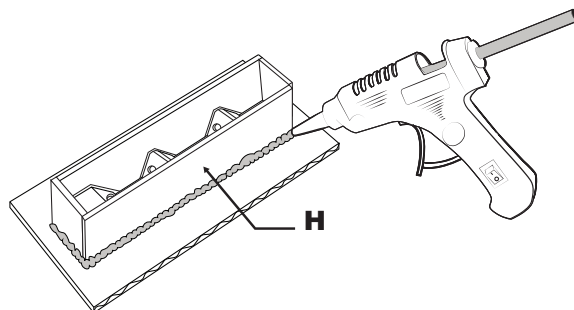
15



Insert the tubes into the holes of the mold. The 4 cm pieces of tubing are placed between C-D, and D-E. Both ends of the 6.5 cm tubing are placed in E, creating a loop for the cord.

**NOTE:** If the tubes are too long and are interfering with one another, trim them shorter. If the tubing loop at the end sticks up too much, you can secure it level against part G with a dot of hot glue.

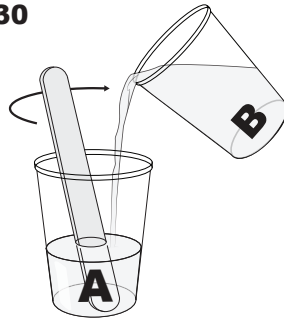
16



Use a hot glue gun to assemble part H onto the remaining edge of the mold outline. Ensure that the laminated side of H with the solid lines is facing the interior of the mold to protect the mold from silicone. "H" should be right side up. The solid lines should align with parts C, D and E inside the mold.

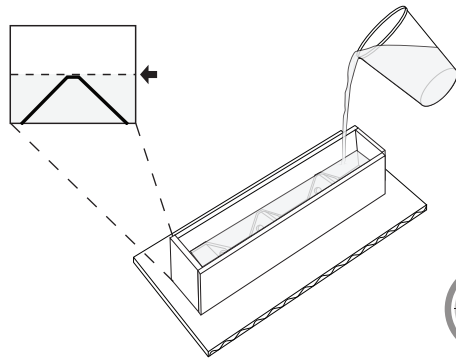
**NOTE:** Secure all of the pieces and corners with the hot glue gun, both inside and outside of the mold. Be sure to seal C, D and D to the side of H.

**17 DRAGON SKIN 30**  
**1A:1B**  
**20G:20G**



Using a mass scale, measure out a 1:1 ratio of parts A and B of Dragon Skin 30. 20 g of part A and 20 g of part B is recommended. Mix the silicone completely with mixing sticks for 30 seconds, or until completely mixed.

**18**

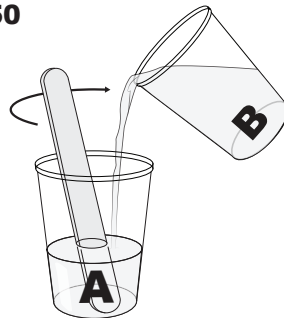


**16 HOURS**

Fill the mold with the Dragon Skin 30 to the fill line on the mold's interior. The silicone will just barely submerge parts C, D and E. Let the silicone cure for 16 hours in the open air. 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.

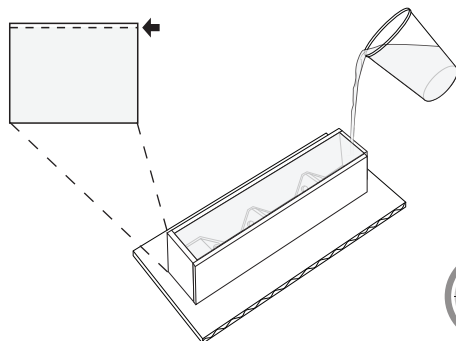
**NOTE:** If you have access to an oven, you can cure the silicone much more quickly. Turn the oven to 70°C (140°F) and let it cure for 20 minutes.

**19 SMOOTH SIL 950**  
**10A:1B**  
**30G:3G**



Using a mass scale, measure out a 1:1 ratio of parts A and B of Smooth Sil 950. 30 g of part A and 3 g of part B is recommended. Mix the silicone completely with mixing sticks for 30 seconds, or until completely mixed.

**20**



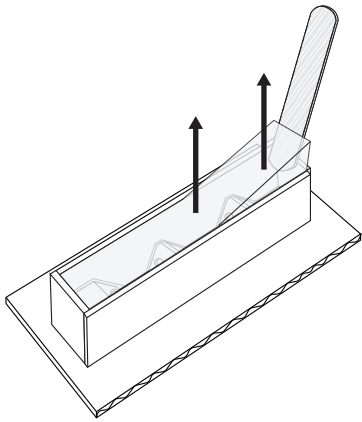
**24 HOURS**

Fill the rest of the mold up with the Smooth Sil 950 to the top of the mold's interior. Let the silicone cure for 24 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.



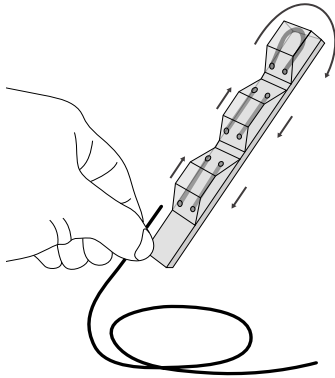
21



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 two-part silicone casting is complete. Use mixing sticks to peel the gripper out of the mold.

**NOTE:** The gripper may be hard to peel out. In that case, disassemble the mold and peel the cardboard pieces away from the silicone finger. Your finger may not be perfectly even, if needed students can trim the edges back with scissors.

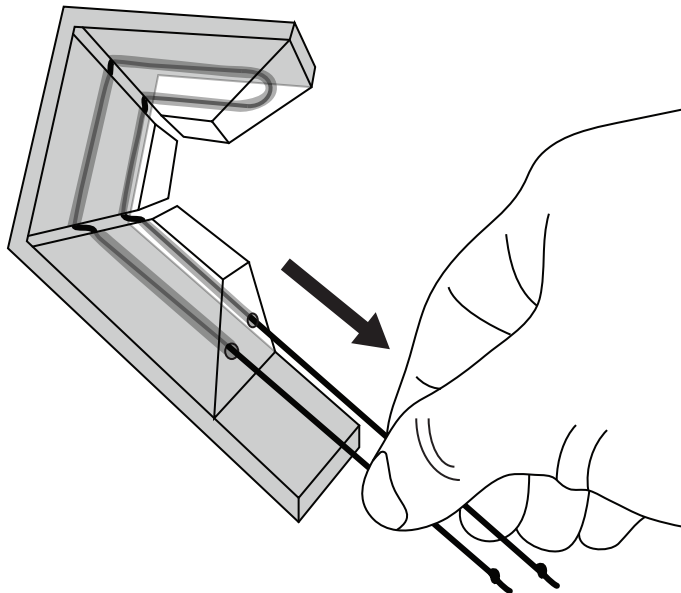
22



Cut enough kevlar cord to run the cord up one side of the finger’s tubing, through the tubing loop at the end, and back down the other side of the finger. Insert the cord into the finger’s tubing as described.

**NOTE:** Have students tie the ends of the Kevlar together to ensure that it does not slip out when pulled.

23



You now have a complete SDM finger. Pull both ends of the Kevlar cord to bend the finger. Have students test their finger by attempting to pick up various sized objects.