ME23N - Soft Robotics for Humanity
Stanford University
Mechanical Engineering
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Lab 4: Fabrics and Wearable Soft Robots

(adapted from the soft robotics toolkit: softroboticstoolkit.com)

I. Overview

In this lab we will investigate fabrics and wearable soft robots. We will construct a pneumatic wrist brace using specialized fabrics and then apply positive pressure in the brace to stiffen the device and wrist joint.

Fabrics have been used in a variety of soft robot technologies using a large range of methods. While all fabrics that are used in soft robotics share a few features, i.e. that they are essentially 2D materials and that they are generally flexible, there are a wide range of different fabric properties that can be used in different ways. Some fabrics are able to stretch in one or both dimensions (referred to as 2-way and 4-way stretch respectively) while other fabrics are designed to be inextensible. Fabrics can also be made with a variety of coatings and treatments that can increase their durability, make them water-tight and air-tight, and allow them to be joined using methods besides sewing. The fabric that we will be using in this lab is a ripstop nylon with a thermoplastic polyurethane (TPU) coating. The ripstop nylon itself is inextensible and robust while the coating allows the fabric to be heat-welded (or heal-sealed) to itself.

One application in soft robotics where fabrics have often been used is wearable robots. Fabrics are a natural choice since they are already the main component in our clothing. Many wearable robots are designed to apply forces to the human body, and more specifically, to apply forces around joints. This has two important consequences: the robot can rely on the human body and more specifically the human skeletal structure as part of the soft robot structure, but careful thought needs to be paid to the interface with the body to allow the robot to apply sufficient forces without discomfort. The use of fabrics has been one approach to creating more comfortable and usable wearable soft robots.

II. Materials and Equipment

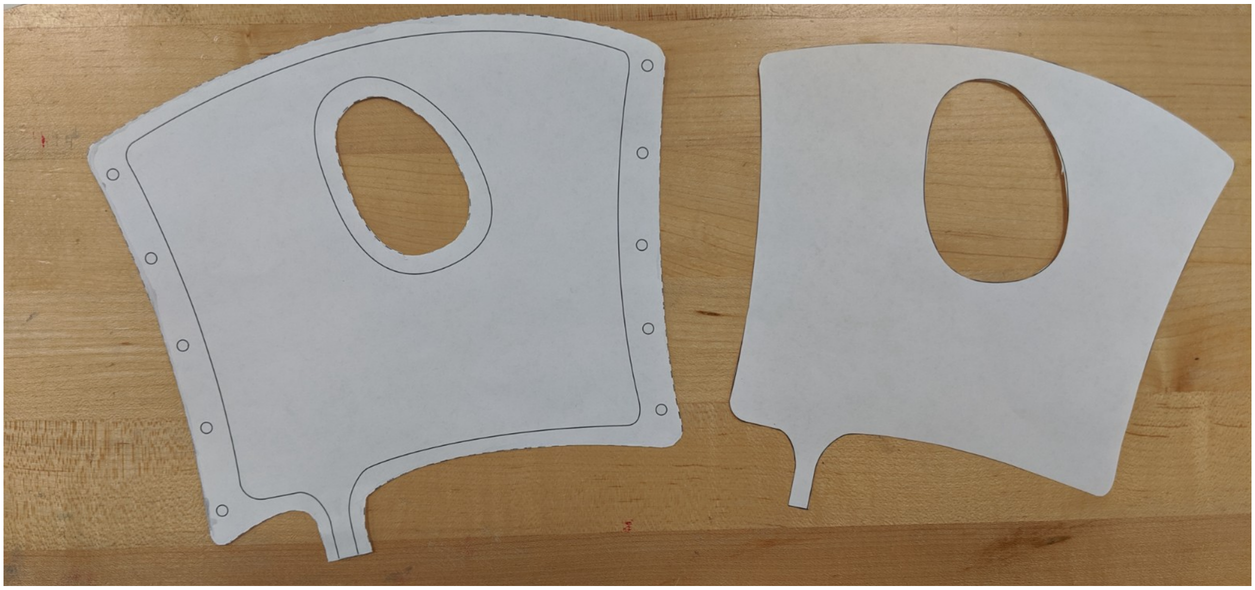
- Heat-weldable Ripstop Nylon (Single side TPU coated)
- Air Tube (4.5/32”)
- Parchment Paper
- Push-to-Connect Connectors and Adaptors
- Elastic Cord (1/8”)
- Spring Loaded Cord Fastener
- Zip ties
- Super glue

- Scissors

- Clothes Iron
- Silver Paint Pens
- Ruler
- Hole punch (1/8”)
- Positive Pressure Hand Pump

III. Steps

1. Start by cutting out the 2 templates at the end of this document. The smaller template (solid line) should fit on the line inside the larger template (dotted line).

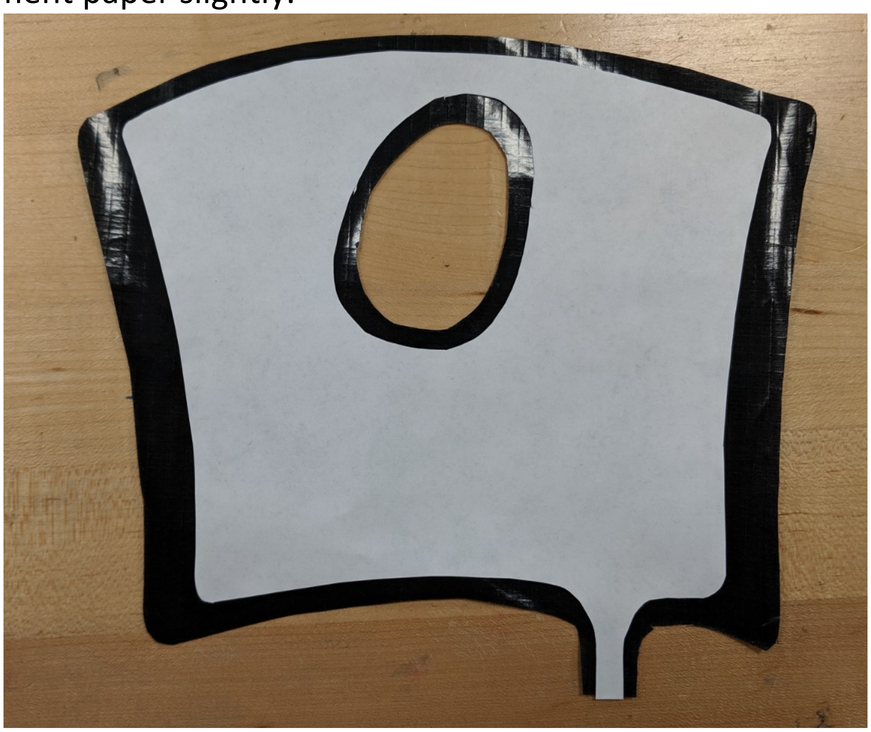


2. Use the larger template to trace out the pattern on the non-shiny (matte) side of the ripstop nylon (use the silver paint pens for best results). **Flip the template over and trace a second pattern.** You need two mirrored pieces (see picture below) so that they will align when the heat-weldable sides are touching.

3. Cut along the traced lines (including the hole). Try your best to be neat so the pieces will overlap when we seal them together.

4. Use the smaller template to trace out a pattern on the parchment paper. Cut out the pattern (including the hole).

5. Check the size and shape of the parchment paper against both fabric pieces. You should be able to position the parchment paper so there is a strip of uncovered fabric around the border, about ¼” thick on the top and bottom edges and just over 3/8” think on the sides. If needed, trim the parchment paper slightly.



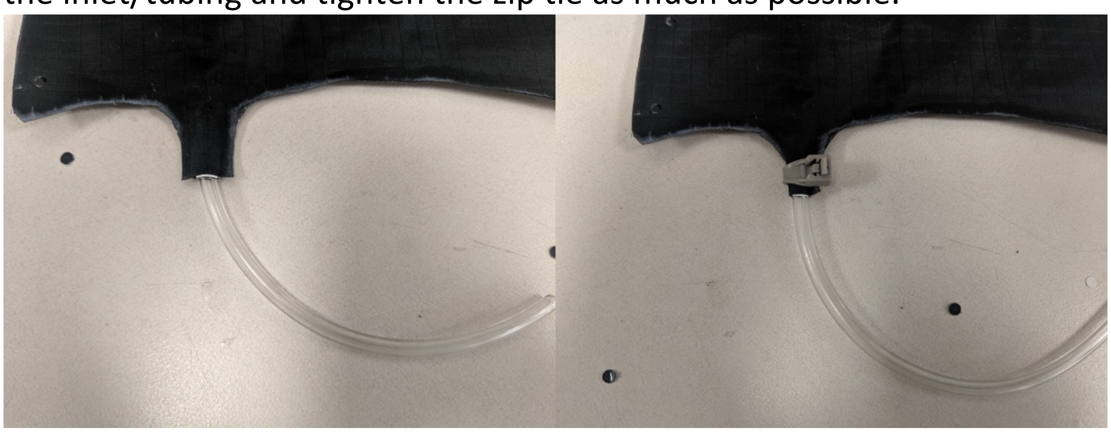
6. Align and stack the three pieces that you cut out, with the parchment paper as the middle layer. The fabric pieces should have the shiny TPU sides facing towards each other (towards the parchment paper, see above picture). Make sure that the narrow piece of parchment paper at the inlet comes all the way to the edge of the fabric, so that the inlet isn't sealed off.

7. Optional: tape down the pieces to the table with masking tape if you are having trouble keeping them aligned.

8. Use the iron to weld the layers of fabric together. **Heat welding takes heat, time, and pressure**, so be sure to keep the iron on each section for a few seconds. The clothes iron should be on the highest setting. Areas covered by the parchment paper will not fuse, so the patterns you cut should create a bladder sealed at the edges and with a hole in the center.

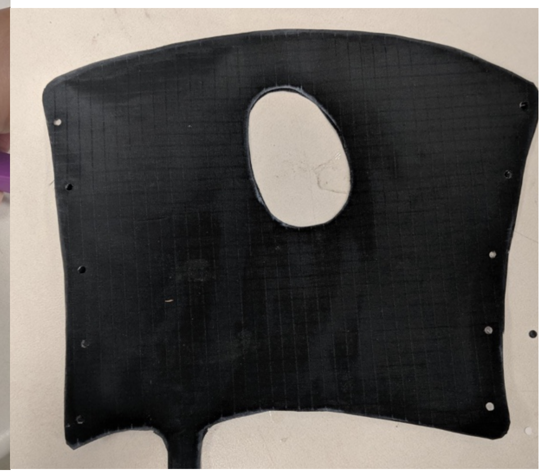
9. Take a 1 ft piece of the air tubing and place a drop of superglue on the outside of the tube near one end.

10. Make sure the inlet of the fabric bladder is open and then insert the glued end of the tubing into the inlet of the fabric bladder. Place a zip tie around the inlet/tubing and tighten the zip tie as much as possible.



11. Try inflating the bladder and note any leaks. Use the iron to reseal any sections that are leaking.

12. Overlay the larger template from above on the fabric and punch holes where the circles are. Be careful not to punch holes in the unwelded areas of the fabric bladder. There should be 5 holes on each side when you are done.

13. Cut 2.5ft of the elastic cord and use it to lace the two sides of the fabric bladder together like a shoe. Add the spring-loaded cord lock on the end when you are done threading.



14. Attach the hand pump to the tube and put the constructed wrist brace on. Test the pressure, fit, and comfort of the wrist brace by inflating it with the hand pump (the person wearing the wrist brace should be in charge of inflating the brace).

15. **Optional:** If you finish with the lab and questions early, try making other shapes of custom heat weldable pneumatic bladders!

IV. Questions

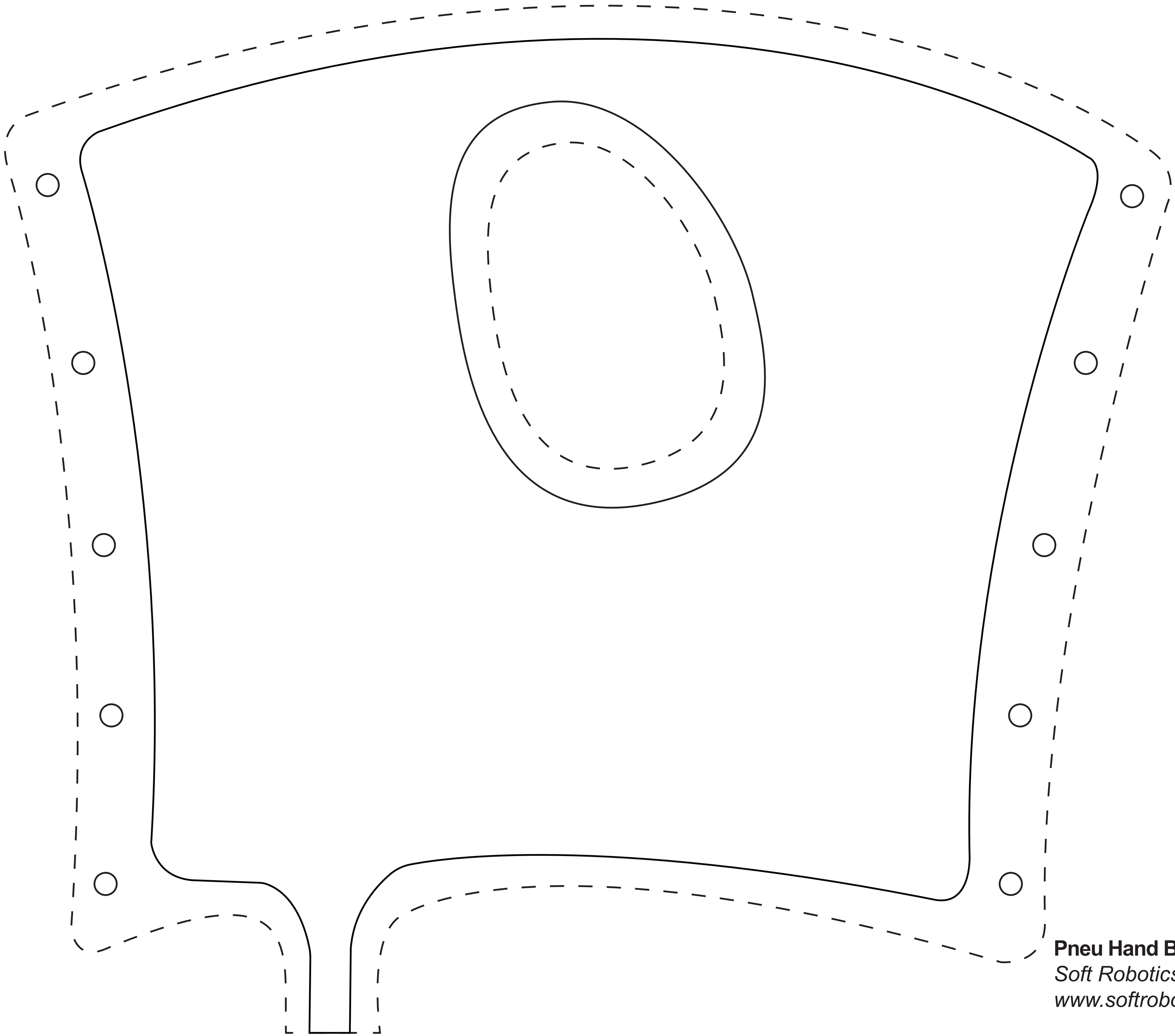
1. Compare the behavior of the pneumatic wrist brace on and off the wrist. When you inflate it with approximately the same amount of air (i.e. same number of pumps) does it have the same “stiffness” in both cases? What is the role of the hand and wrist in the function of the device as a brace (does it work as a brace without the hand inside)?

2. Describe the important features of the wrist brace as a wearable device. What allows it to fit well? To be comfortable? And to perform its function? How does this compare to traditional wrist braces?

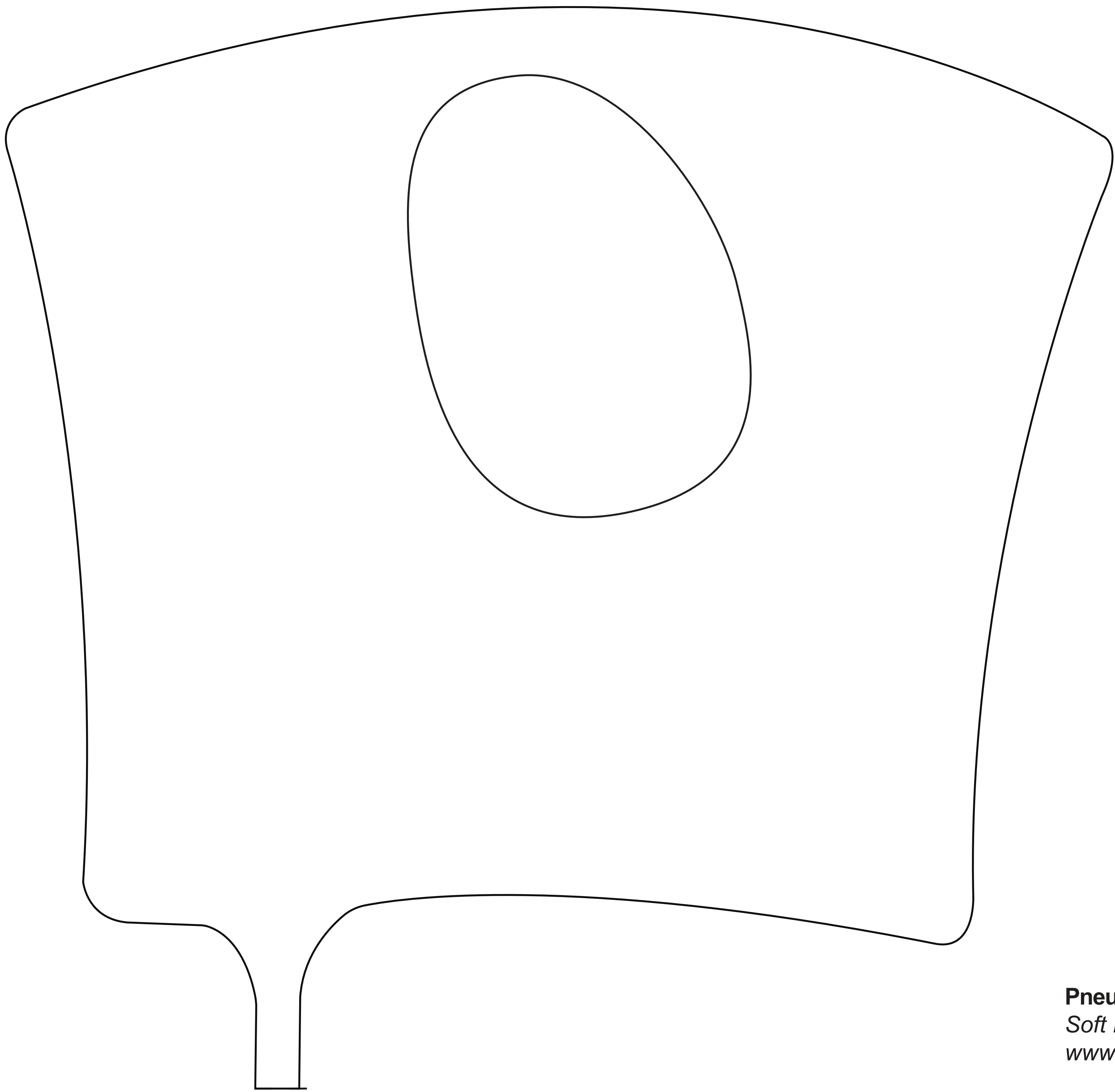
3. What ways could you improve the fit, comfort, or function of the current device? How could we incorporate techniques and materials seen in previous labs to create an “active” wearable soft robot?

4. In what other ways and for what other applications could you use shaped pneumatic bladders like those created using heat-weldable fabrics in this lab?

5. Any other thoughts?



Pneu Hand Brace - Template
Soft Robotics Toolkit, 2017
www.softroboticstoolkit.com



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