

Fabrication Guide: Low-Cost Dog Prosthesis

The purpose of this guide is to explain how we fabricated limb prostheses for a dog with forelimb injuries. The fabrication technique detailed is intended to be low-cost, and achievable without advanced technical training or access to specialized equipment. The design outlined below was for a small dog that could safely bear weight on his elbows. The dog's forelimbs were injured prior to his adoption, resulting in fusion of the elbow joints at ~90 degree angles and limited functional use of the limbs below the elbows. In this case, the dog's forelimbs were not amputated, but rather they had limited functionality. The dog was forced to scoot around on his elbows, limiting his ability to walk and causing pain due to scrapes and cuts on his elbows.

The goal of this project was to design a prosthesis that would protect the dog's elbows and improve his ability to walk. This step-by-step guide describes how our design was fabricated, in the hopes that it can help others to create similar prostheses for more pets with disabilities. Creating a prosthesis is a very individualized process, depending on a pet's specific needs. These exact steps may not represent the solution for every pet. In particular, this guide does not cover how to build a prosthetic socket for a dog that is completely missing its limb due to amputation. Nevertheless, the general fabrication approach may be used to create other unique and beneficial pet prosthetic designs.



Disclaimer: General instructions are provided to assist with fabrication of prostheses for dogs and other pets. Please build and use such prostheses at your own risk. It is recommended to consult with a qualified veterinarian to assess the health and special needs of your pet, prior to fabricating or fitting your pet with any prosthesis.

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Materials (available from Amazon.com and other vendors)

Thermoplastic (Kydex)

Foam

Nylon straps

Buckles

Super glue

Padding/cushioning material

Adhesive hook and loop (Velcro)

Hot glue sticks

Tread

Tools (available at most hardware stores)

Pencil

Ruler

Flexible tape measure

Metal shears

Heat gun (or hair dryer)

Work gloves

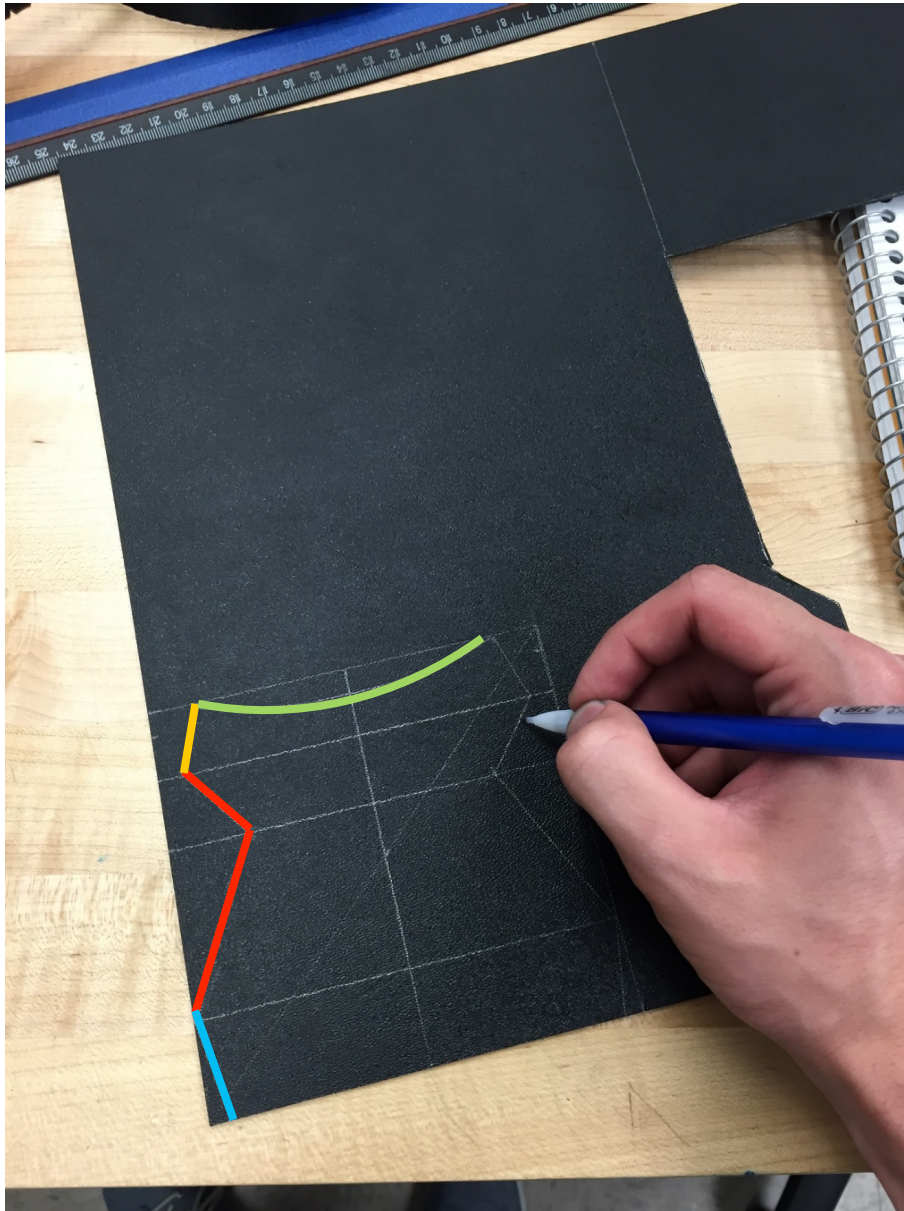
Box cutter

Silver sharpie

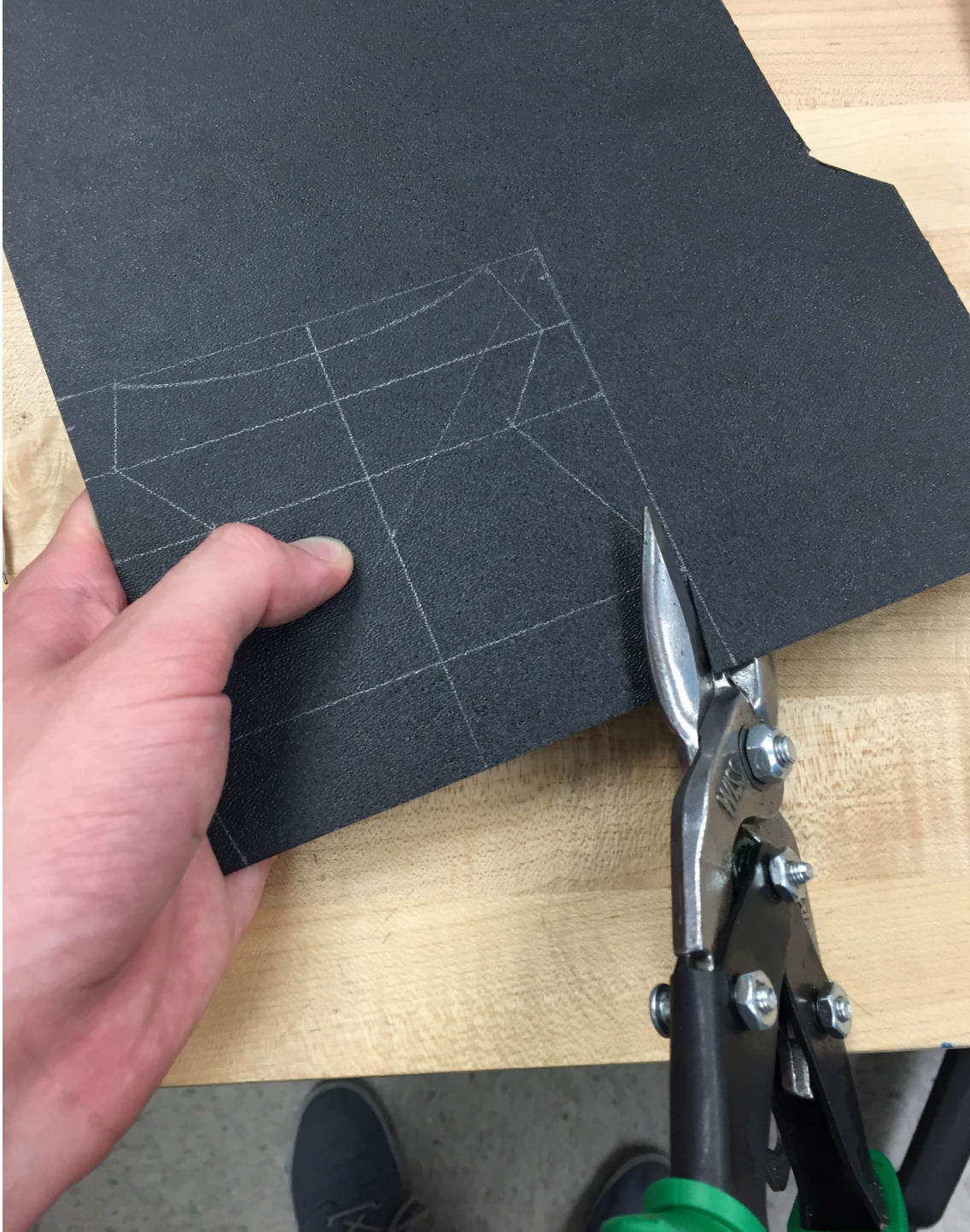
Scissors

Hot glue gun

Step 1 – Cutting out the shell



Select your thermoplastic material. We used Kydex, which is available in multiple thicknesses (e.g., our vendor had Kydex ranging from .028" to .118"). We selected a thickness of .06", which was stiff enough for our 12 pound dog. On the thermoplastic sheet, use a pencil to draw the outline of the desired shape. To determine the shape, first use a tape measure and make measurements of the pet's limb. Estimate how wide the shell needs to be to wrap around the limb; how long it needs to be to cover the desired length of the limb; and where to make gaps (red lines above) in the material to allow for corners or other curves. We initially created our shell to extend from the elbow all the way to the tip of the dog's foot, but upon testing we found this to be too bulky and to limit the dog's ability to maneuver his legs. It was also important to ensure that the shell did not vertically extend too high on the limb, to avoid jabbing uncomfortably into the dog's torso during movement.

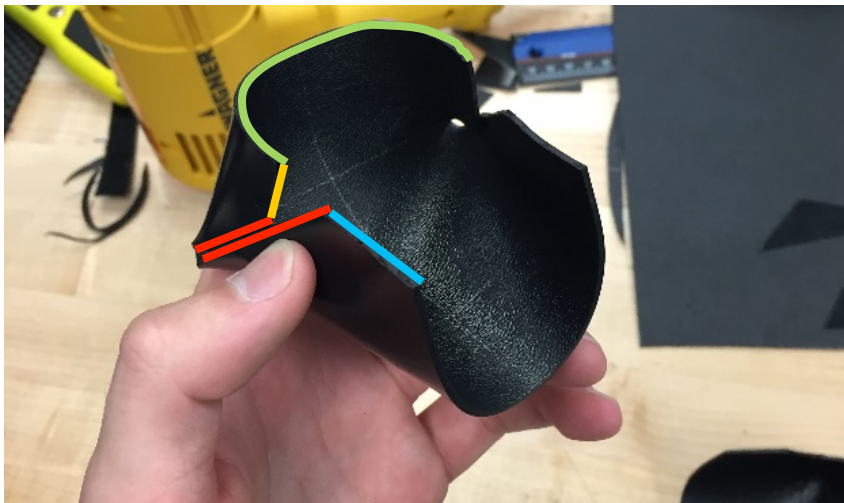


Cut out the shape. Metal shears work well. Box cutters also work well but make it more difficult to cut along curves.

Step 2 – Molding the shell



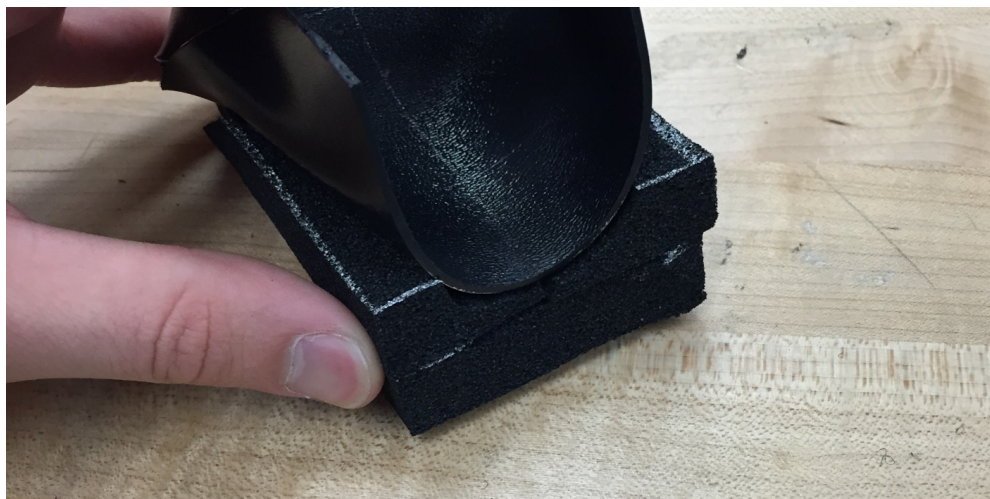
Heat the thermoplastic shell until soft and pliable, bend as desired and hold until cool and stiff. Keep heating and shaping the plastic until the desired shape is reached. We used a heat gun and it worked well, but hair dryers and other heat sources will work too. Caution: wear work gloves because the heat gun blows very hot air and the heated plastic is too hot to hold with bare hands. The shell is the rigid structure that will hold the pet's limb so make sure it fits well/snugly. This may take some trial and error. Try testing the fit on your pet and making adjustments as needed. The benefit of using thermoplastic for the shell is that heat can be re-applied at any stage of the design process to further refine or adjust the shape. This allows for much faster revisions than alternative fabrication methods such as 3D printing. Leave enough space on the inside of the shell for a layer of padding (to be added later, for comfort).



Step 3 – Creating the foam bottom



Create the bottom of the prosthesis. We used foam to create the bottom/base of the prosthesis. This portion of the device could be designed in many different ways, and with different materials, depending on the specific needs of the pet. We used two layers of foam, one on top of the other, glued them together with super glue, and cut out part of the top layer to fit snugly against the contour of the plastic shell. This foam added about 2 cm of height under the shell, and provided a stable base for the dog to walk on. We chose the foam by its firmness. It was stiff enough to support the weight of the dog and prevent rolling laterally, but soft enough to conform to the ground slightly and cushion the impact from each step. The reasons we created the bottom this way were because we found it provided a good trade-off between cushioning and stability, it was lightweight, and it allowed the dog to retain limb range of motion. This design also prevented the device from twisting/slipping on the limb, which frequently resulted from taller (more stilt-like) design alternatives that we tested. Taller prostheses may be feasible if the shell is well fit and securely affixes to the pet's limb.



Step 4 – Assembling the straps & buckles



Cut straps that are longer than you expect to need to wrap around the limb. The straps can be cut shorter later if necessary. Heat the ends on the straps to prevent fraying. We used ½ inch nylon straps.



Secure the strap to the female end of the buckle by looping the strap through and gluing it to itself. We used super glue. Then loop the other end through the male end of the buckle. Do not glue the strap to itself on this end, this is the adjustable end of the strap. We used two buckle straps, one to wrap around the upper arm (above the elbow) and one to wrap around the forearm (below the elbow). Velcro is an alternative that could be used in place of buckles.



Place the strap in the desired position on the shell and super glue a portion of it to the shell.



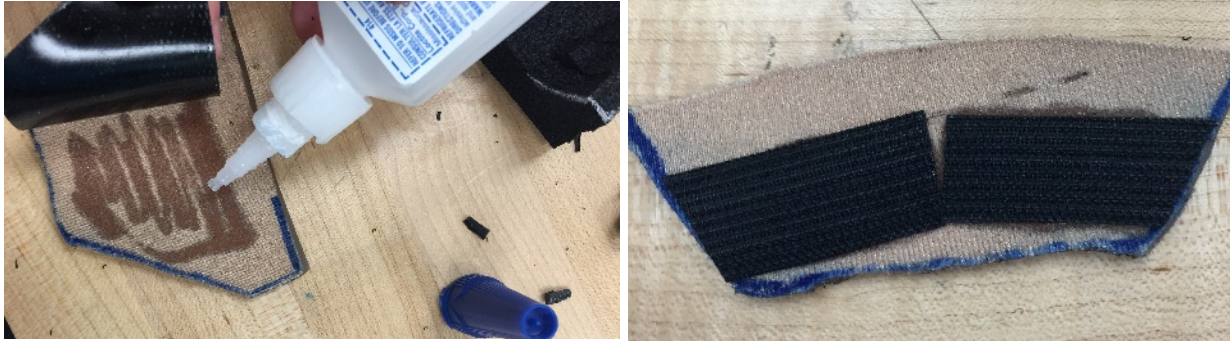
To prevent the straps from slipping out of position you might also want to add some small guards. These serve the same purpose as belt loops in a pair of pants. To do this cut a small piece of the thermoplastic, heat it and bend it. Then glue it to the shell. We used hot glue to attach these.

Step 5 – Inserting padding into the shell



Add a layer of cushioning inside the shell to improve fit and comfort. We used the same type of material that is used in prosthetic liners for human amputees (thermoplastic elastomer) because we had scraps of this material available. However, other padding or cushioning materials should also work. Cut the padding into a shape that fits well in the shell. We found it was easier to make the padding in two pieces, for the areas above and below the elbow.

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Once the cushioning material is cut out, secure it inside the shell using adhesive-backed hook and loop (Velcro). Glue the hook side to the cushioning material and the loop side to the shell. This is to prevent any accidental poking by the hooks. We used super glue to make sure the hook and loop stayed attached.



Finally, press the cushioning material into the shell.

Step 6 – Attaching the bottom



Attach the foam bottom to the underside of the shell. We used hot glue to create a more permanent connection. Initially during testing we used adhesive-backed Velcro to attach different bottoms. After trying multiple options and allowing the dog to walk on them we permanently attached the one that worked best.

Step 7 – Adding the tread



The final step is to use a tread material to cover the bottom. Tread, a durable material similar that found on the bottom (outsole) of your shoes, helps prevent wearing of the foam. We used hot glue to attach the tread around the foam.



Now the prostheses are ready to try on!