Make:

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THE COSPLAY COLLECTION

CyberHead Designs

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Expert cosplayers share their tips, tools, and ingenuity to inspire you to get started

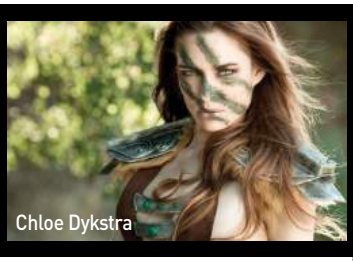
Written by Bonnie Burton

Clever Couture

Lee Camara


Lee Camara


Lee Camara


Chloe Dykstra


Holly Conrad

Cosplay isn't just about posing for photos at conventions anymore. Cosplayers are impressing fans and makers alike by constructing their own original costumes that include elaborate armor, movie-ready prosthetics, special effects makeup, and intimidating weaponry.

Our favorite cosplayers — some of the most talented in the world — share their design and fabrication processes, favorite moments, and inspiring advice for newbies hoping to transform themselves. If you're bummed Halloween only comes once a year, this might be the hobby for you.

Lee Camara

fevstudios.com

My first "costume" was in 1996. I butchered some sweatpants to dress up as Haohmaru from *Samurai Spirits*. I later pulled out the costume when I went to my first convention in 1998. The convention bug bit me, and I attended them by participating in artist alleys. I began adding a prop or two as a display piece, and cosplayed if there was room to fit the costume in the suitcases. In 2004 I began doing commissions.

What's your process when making a costume?

I'll go through concept art and any other official images for reference. I'll sometimes make a hybrid of the design and sneak in personal touches.

I'll use Inkscape to create an orthographic drawing at full scale. If it needs to be sculpted, I'll just work from the reference images.

Additional sketches are done should the prop have special requirements, like the need to disassemble, safety, convention policies, weight, and other factors. Questions like "How quickly can I use the bathroom?" are also taken into consideration.

I have a laser cutter, and will cut some elements directly from the vector files. Most of the work is done using hand and power tools. A Dremel, jigsaw, and my belt sander are the most frequently used, and the detail work is done with hand carving, sculpting, and filing tools.


Chloe Dykstra


Holly Conrad

For smaller accessories and sculpting in general, my preference is polymer clay. It can be baked in a toaster oven, carved, drilled, added upon, re-baked multiple times, and polished to a shine. Most items get molded and cast in resin.

What has been your favorite cosplay moment?

Meeting people who tuned in to my streams, or used tutorials to help them are my favorite. Seeing that it actually helped someone makes it all worth it.

Advice for aspiring cosplayers?

If you've never done a costume before, pick a smaller project that isn't too difficult. There are a ton of resources online. See if there are makerspaces or costuming groups that get together and build in your area.

Chloe Dykstra

chloedykstra.com

In 2010, my friends were making a web series called *There Will Be Brawl*, which was a dark re-imagining of Nintendo's lore. They asked me if I wanted to play Malon (from *Zelda: OoT*) as a prostitute. The only correct answer to that question is yes. I threw together a Malon cosplay from thrift store items and my closet, and that was the beginning of the end.

What's your process when making a costume?

I pick a costume based on my abilities and Frankenstein the whole thing. Every piece is planned — what materials, what process. It's all trial and error.

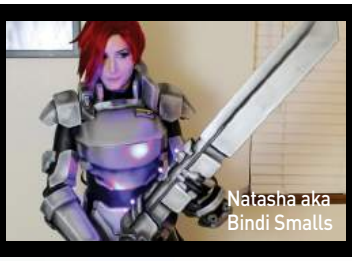
What kind of tech and equipment do you use?

I'm fairly low tech. You can make anything out of EVA foam.

Any favorite pieces?

I built a robot on top of a modded R/C car in a day. It

Henry Mei, Lee Camara, Holly Conrad, Paolo Cellammare, Greg de Stefano


Natasha aka Bindi Smalls


Tim Winn


Tim Winn


Tim Winn


Natasha aka Bindi Smalls


Tim Winn

wasn't perfect, but I was on a serious time crunch, as well as recovering from surgery.

Advice for aspiring cosplayers?
Keep failing. Embrace it, that's part of the fun of it!

Holly Conrad

hollyconrad.com

I was first interested in cosplay when I was around 5 years old. My favorite costume was a green pillow I taped around my back — a Koopa from *Super Mario Brothers*. After that, I got into going to the Renaissance Faire as a Tiefling from *D&D*, and the rest is history.

What's your process when making a costume?
I love to illustrate, so I take an artist's approach. I like to do my own spin on them, from using interesting, unique materials to aging costumes in the dirt in my backyard. I love being messy when the costume requires it.

What kind of tech and equipment do you use?
I use a lot of molding and casting; a lot of resin and cloth. I've made a few costumes from *Animal Crossing*. I had to challenge myself and do a lot of sewing on top of the foam fabrication. I like to stick to foam and clay. I've been learning to wet felt, which is super exciting and interesting. I've also learned to felt my own witch hats.

Any favorite pieces?
Those that I have a real emotional connection with. I loved being Commander Shepard because she was such a strong character. My love of storytelling and characters is what drives me to cosplay.

What has been your favorite cosplay moment?
Meeting other people who love the things you do. When I made a costume of the Lady of Pain from my favorite *D&D* setting, one of the creators commented on my blog that I'd done the character justice. It has nothing to do with the likes, and everything to do with the spirit of why we create.

Advice for aspiring cosplayers?
Be true to yourself, ignore the drama that a large community comes with. Make anything. As long as you have passion and drive and kindness, people will come to you and love your work.

Natasha aka Bindi Smalls

bindismalls.com

I got into cosplay after having a habit of making extravagant Halloween costumes. I was disappointed that I could only flex my creativity for this once a year, so cosplay was the answer.

What's your process when making a costume?
I 3D model, 3D print, sew, paint, and do leatherwork for all of my costumes. 3D modeling and 3D printing are my favorite to make armor and props.

What has been your favorite cosplay moment?
When I get to cosplay with my friends as characters from the

Bindi Smalls, Boston McConnaughey, Bryan Humphrey - Mad Scientist with a Camera, Marvin Reyes - CyberHead Designs, Adam Grumbo Films - facebook.com/grumbo


Amie Danielle Dansby


Amie Danielle Dansby

BONNIE BURTON is a San Francisco-based author and journalist who writes about pop culture, crafts, and all things geeky. Her books include *The Star Wars Craft Book*, *Crafting With Feminism*, and more. She writes for CNET and hosts the "Geek DIY" show.

same video game or series. It's best to cosplay with friends.

Advice for aspiring cosplayers?
Take your time. It's okay to push your deadline to get it right.

Tim Winn

facebook.com/Timforthewinn

When I was a kid my mom made the best costumes. I didn't know what cosplay was back then. Only in the last two years have I turned it into a full time job.

What's your process when making a costume?
I'm known for my foam fabrication. I start with research and use 3D modeling to create templates, which I then convert into 2D patterns. I transfer that to the foam and put it all together like a puzzle.

What has been your favorite cosplay moment?
A few years ago, I was asked to play *Halo* with a very sick young boy. It wasn't a huge event, it was just me dressed as a Spartan from *Halo*, meeting this wonderful family and playing a game we both loved. We had a great time. A few weeks later he passed away. That was hard, but the memory was one of the best I have while cosplaying.

What are you making next?
My job is to create the amazing costumes that you see on the Freakinrad YouTube channel, Twitch, and various commercials. I'm working on a tutorial series about how to build the things we make, and to help people get started.

Advice for aspiring cosplayers?
As long as you keep trying you will succeed.

Amie Danielle Dansby

amiedd.com

The first character that had me interested in cosplay was Anna Valerious from *Van Helsing*. I started with every maker's gateway drug: cardboard and foam. I started in 2012, and it brings me joy to introduce others to the chaos of making.

What's your process when making a costume?
I'm a software developer so I practice project planning for work and for cosplay. I use Trello for my programming sprints, personal projects, and cosplay. I storyboard my cosplay projects into categories. I break down every piece think I'll need, document materials I've used, what worked, and what didn't.

What kind of tech and equipment do you use?
I'm working on a Rufio cosplay and I used a laser cutter for some of the bamboo and leather pieces. I've utilized foam, Worbla, woodshop tools, blacksmith forge, 3D printing, molding and life casting, sewing, electronics, servo motors, and Lego. Each cosplay I have learned a new skill.

Any favorite pieces?
I was really proud of my sword scabbard I made for my Ciri cosplay. The base was cereal boxes. You don't have to spend lots of money to make something look great. Another

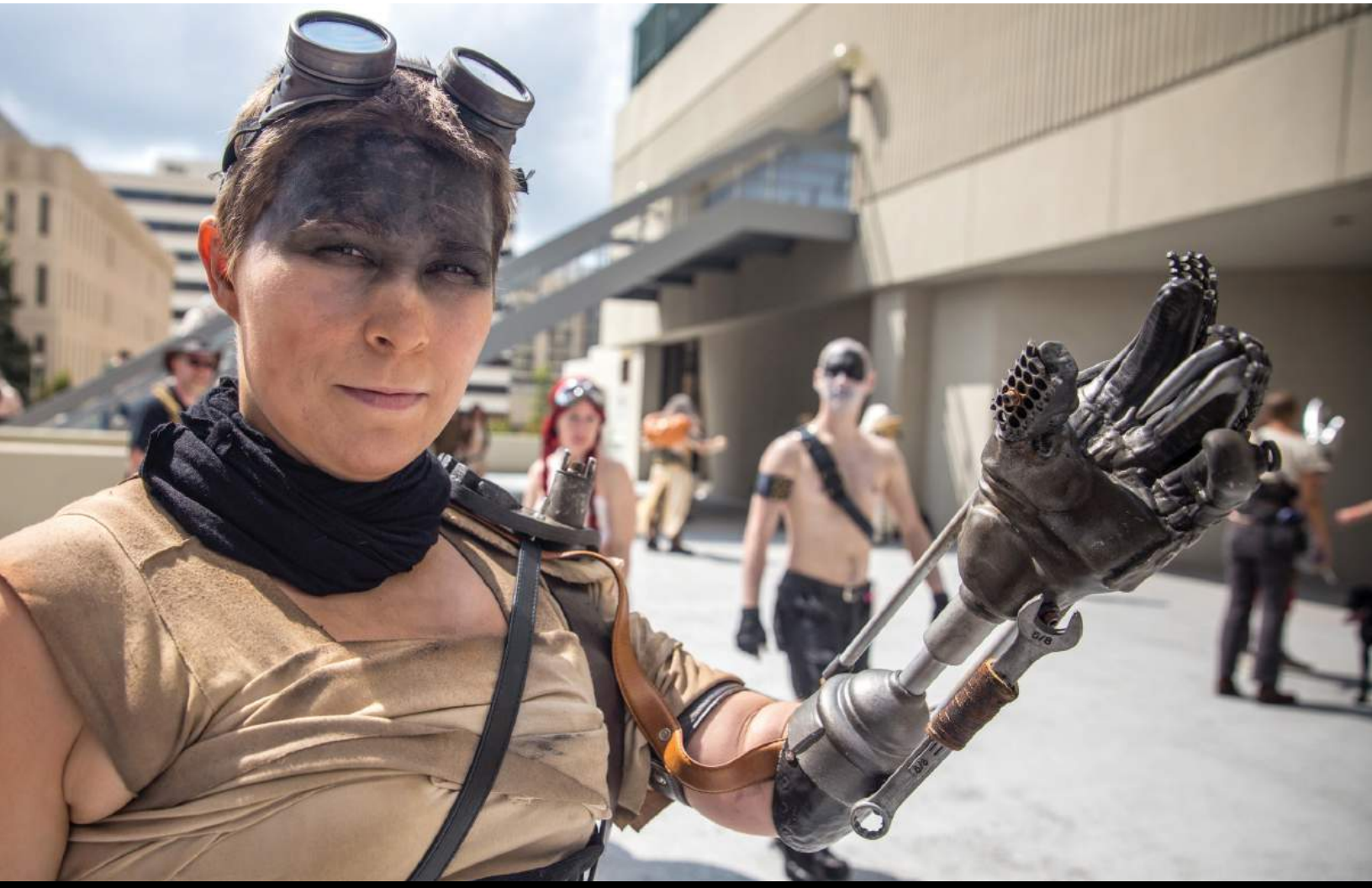

Amie Danielle Dansby

was the Princess Hilda's staff. I designed the parts in Fusion 360, 3D printed the parts and electronics in two days. This was the first time I designed the CAD parts to fit my design, electronic components, and schematics. Previously, if I needed space, I'd make my design in Fusion 360 with a square or area big enough to shove all the wires and parts into to stay hidden.

What has been your favorite cosplay moment?
We lost my mom to breast cancer. My dad filled the role as mom and dad. We have gone to conventions before, but last year he surprised me at a con and dressed up as Mario riding a blow-up Yoshi costume. My dad has always supported me.

Advice for aspiring cosplayers?
Don't be afraid to be a beginner. I've learned to solve problems, and try new things, and along the way I've met some of the most passionate makers from around the world.

Cosplay Illustrated – facebook.com/CosplayIllustrated, Amie Danielle Dansby, Phoenix Taylor Photography



Building Furiosa's Bionic Arm

Inspired by *Mad Max: Fury Road*, I built a real prosthetic arm for an amputee cosplayer

Written by Michelle Sleeper

Every once in a while, a character in film inspires you to make something you could only dream about.

Back in 2015, I was introduced to a cosplayer who wanted a truly unique prop made. Laura from Amplitude Cosplay is a left arm transradial amputee, meaning that she is missing her left arm below the elbow, since birth. She's not afraid of displaying her unique body with her costumes — we had originally connected because she wanted an exposed arm endoskeleton like from the film *Terminator*, and that was at the top of my list of dream projects.

Then the movie *Mad Max: Fury Road* came out, and with it the character of Imperator Furiosa, and she changed all our plans. Laura had authored an in-depth piece on her blog about representation of amputees and how Furiosa was masterfully written. Beyond that, her unique bionic arm was completely awesome, and both Laura and I knew that we had to bring both it and her to life.

MICHELLE SLEEPER is an Atlanta-based maker, artist, and educator. She specializes in special FX and prop and costume making. You can see her work at msleeper.com and on Instagram at @overworlddesigns.

I have made plenty of prop and costume pieces before, but this was the first prosthetic I had ever made, and there were a lot of really exciting challenges. Unlike a space gun or video game armor, there wasn't a lot of wiggle room for fitting — the bionic arm had to fit her perfectly. So to start out we made a simple life cast of her arm. The mold was made using alginate, a cheap and easily found material for life casting, and from the mold we cast a

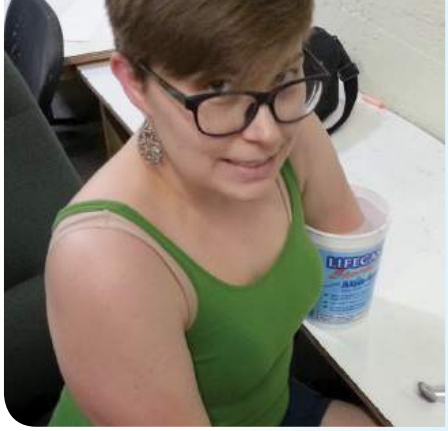
duplicate out of plaster.

In order to design the 3D model accurately to fit Laura, we then used the plaster cast to create a 3D scan using photogrammetry software. Using the life cast was far more ideal than scanning Laura directly; having her sit perfectly still while we performed a scan would've been next to impossible. The plaster cast also doubled as a stand-in for her during the fabrication process — since I couldn't test-fit the prop on myself, the plaster cast was used to make sure everything fit in between Laura's visits to my shop.

Once the digital model was finalized and as close to "screen accurate" as we could get it, we sent it off to the 3D printers. A lot of the detail parts were cast from real-world items, such as the wrench tied to one of the forearm shafts, and other parts were laser-cut out of acrylic and heat-formed into their proper shape. Finishing up the parts from there was fairly standard post-processing procedure, and once everything was sanded smooth and painted, we then had to attach it to her.

The mechanical arm seen in the film is a mixture of practical and digital effects (there's actually only one shot in the whole film where the arm is fully practical!), but since we couldn't use movie magic in real life at a cosplay convention, we had to toe the line between accuracy (to the look of the prop in the film) and actually making it wearable. A few key scenes helped us understand how the film prop was worn; there was a series of leather straps running up the arm to her shoulder, and from the shoulder to a waist harness. The leather re-creation worked really well, and Laura, who doesn't normally wear a prosthetic, says it was comfortable.

On the day of the convention I delivered the prop to Laura and got to see the final costume all together. The finished product was astounding, and it was a lot of fun catching con-goers doing double takes as they tried to figure out how she was hiding her "real arm." Even when the truth was revealed, a lot of people still thought there was some sort of trick, but the reality was so much better — an empowering and real-world prosthetic for a special cosplayer.



Life casting Laura's arm.

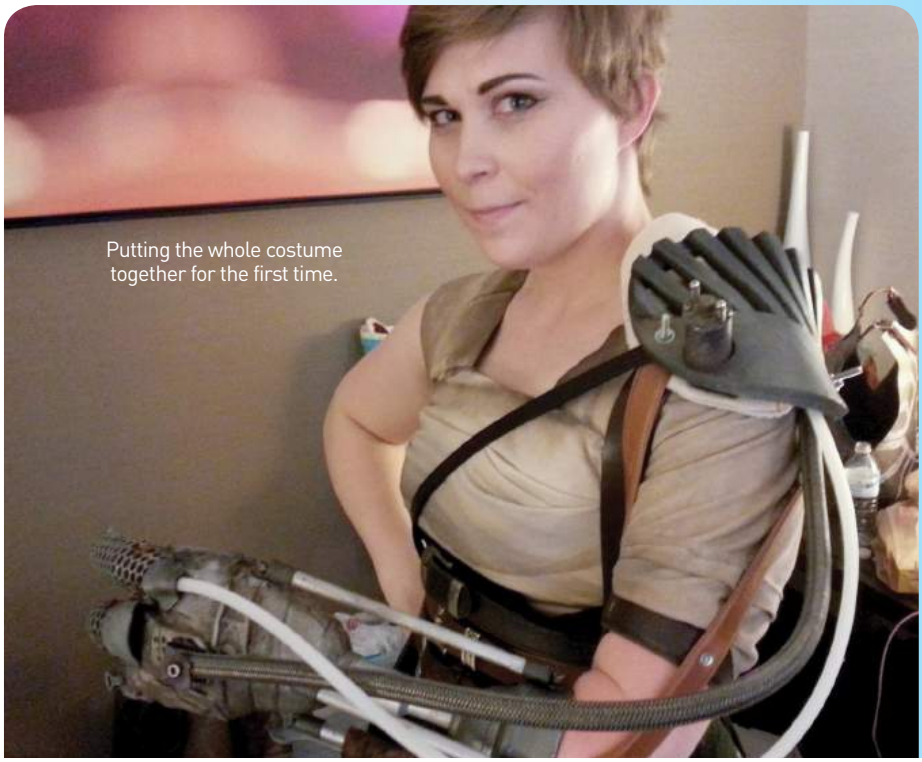
The hand, fresh off of the 3D printer.

Early stages of sanding, filling, and priming the prop arm.

The bionic arm finished and ready for battle in the Wasteland.

Close-up detail of the wrench, molded and cast from a real wrench!

Test-fitting the arm on Laura before we fabricated the leather harness.



Putting the whole costume together for the first time.

Norman Chan, Michelle Sleeper

Altered Apparel

Written and photographed by Lisa Mecham

Add sass to your simple sweater with ribbon and grommets

TIME REQUIRED:
1 Hour

DIFFICULTY:
Easy/Intermediate

COST:
$5–$7

MATERIALS

- **Sweater**
- **Polyester fabric** for lining
- **Grommet set, ½"** such as Dritz #44389
- **Satin ribbon spool, ½"**

TOOLS

- **Fabric scissors**
- **Tailor's chalk and ruler**
- **Basic sewing machine**
- **Hammer**
- **Dressmaker pins**

LISA MECHAM spends her days running a DIY fashion blog and her nights completing messy projects with her four kids. You can find more of her refashion and other DIY projects on her website, CreativeFashionBlog.com


A


B


C


D


E


F


G


H

Ribbon really dresses up a basic knit sweater, and, unlike the bare-shoulder versions, a lace-up sweater will still help you stay warm. Here's how to make your own by repurposing one of your pullovers.

1. CREATE A LINER

Start out by cutting a small rectangle of fabric large enough to cover the neckline of your sweater. Lay the rectangular fabric piece over your sweater and use scissors to cut along the neckline so they match (Figure A). Remove the lining and set aside.

TIP: Be sure your lining piece of fabric is 2" longer than your lace-up section of the sweater. This will help it all lay flat once you are done.

2. MEASURE THE LACE-UP SECTION

Decide how deep you want the lace-up part of your sweater to go. Use tailor's chalk to mark the line down the front of your sweater (Figure B). This will be used as a guide to be sure the fabric doesn't fray while you're working with it.

3. SEW AND CUT SWEATER

Use your sewing machine to stitch a line starting from the center of your neckline (Figure C), down the right side of the line, across the end of your tailors chalk line, and back up the left side of the line to create a long, skinny rectangle. This makes it easy to cut open a chunky knit sweater without the yarns and threads coming undone.

Now cut along the line you have drawn to open your sweater (Figure D).

4. ATTACH LINER

Lay your fabric lining over the front of your sweater again (right sides facing together) and pin into place along the neckline. Cut a line through the rectangular fabric as well to match the cut on your sweater. Again, make sure your lining drops 2" below the cut on the front of your sweater.

Head back to your sewing machine and sew the lining to your sweater (Figure E). Start at a corner of the neckline and continue all the way down the slit, up the other side, and finish on the other side of the neckline. Flip the lining inside your sweater.

5. PLAY WITH GROMMETS!

Starting from the top of the neckline, I measured 1" down and placed my first grommet (Figure F). From there I continued punching grommets every 2" and setting them with a hammer (Figure G). You can fold your sweater in half and use dressmaker pins to mark where to place matching grommets on the other side.

TIP: A grommet kit is the easiest way to get all the tools you'll need for this project without wasting your money on things you don't. The set I used is less than $9 and includes the right size grommet setter and enough grommets to complete your project.

Now lace it up with some pretty ribbon (Figure H) and you are all set!

FABRIC FRIENDLY

While there are lots of Pinterest tutorials on how to refashion a basic cotton sweater, I wanted to create one that walked you through some simple hacks that make it possible to work with more complicated fabrics like chunky knits or loose weave. This way, no matter what textile you're dealing with, you can always create the finished look you want.

TIME REQUIRED:
3–4 Hours

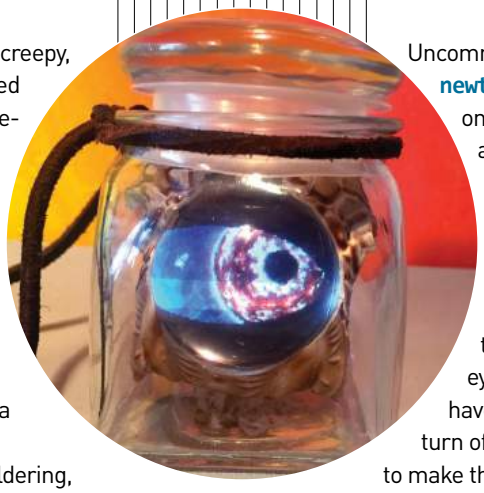
DIFFICULTY:
Intermediate

COST:
$60–$90

Eye of Newt

Written by Erin St. Blaine

For a charm of powerful trouble / Like a hell-broth boil and bubble!



Keep watch with a creepy, compact, animated eyeball. Put it in a wide-mouth jar and add it to your potion shelf, or attach a leather thong to wear it like a pendant around your neck. This guide is based on the Uncanny Eyes project by Phil Burgess, with a Halloween-y twist.

Before you start soldering, get all your software running and uploaded to your Teensy microcontroller. Getting the code loaded up first will make it easier to troubleshoot any soldering or build issues later on.

Software setup is fully covered in the Uncanny Eyes project at learn.adafruit.com/animated-electronic-eyes-using-teensy-3-1/software. And you'll find the hardware build at learn.adafruit.com/eye-of-newt.

CODE DOWNLOAD

Make sure you have installed everything listed below before moving on:

- Arduino IDE
- Teensyduino Installer
- Libraries (installed via the Arduino IDE and NOT the Teensyduino installer):
  - Adafruit_GFX
  - Adafruit_SSD1351
  - Adafruit_ST7735
- Python PIL Library (only if you want to add your own custom images)

Now download the project code from github.com/adafruit/Teensy3.1_Eyes/archive/master.zip. Inside you'll find a folder called *convert* that contains several different image folders and a Python script, and another folder called *uncannyEyes* that contains the Arduino sketch.

Open the sketch, *uncannyEyes.ino,* in the Arduino IDE and then make sure to select 72MHz as your CPU speed. (If your eye looks grainy, this could be your problem. It doesn't work right at the default CPU "overclock" speed.)

Upload the sketch to the Teensy as-is for testing, and make sure that it works before making changes.

Now look at the *uncannyEyes.ino* sketch. At the top you'll find several eye options.

Uncomment the `#include newtEye.h` line to turn on the newt eye option, and comment out the `#include defaultEye.h` line (Figure A). There can be only one!

This code defaults to rendering two eyes. Since we only have one eye, we can turn off the second one to make the code run faster. Just a few lines down, look for the `eyepins[]` array and comment out the second line within (Figure B) to turn off the right eye.

CUSTOMIZING THE GRAPHICS

I wanted an eyeball that looked as much like a real newt's eye as possible. I did an image search and found one I liked (Figure C).

Then I used Photoshop to "unroll" the eyeball so the software can draw it correctly. After some cropping, zooming, and judicious use of the Liquify filter, Figure D is what I ended up with.

The sclera (the white part of the eye) on a human (Figure E) looks really different from a reptilian eye. I wanted a more newt-like look, so I inverted the colors in Photoshop, then added a black circle to the center to keep the pupil dark. It took me several tries to get it right, but I'm really happy with the end result (Figure F). These images are included with the code download, and the process is explained thoroughly over at the Uncanny Eyes guide. Go nuts and create your own unique look.

EYE ORIENTATION

There's one more change we can make in the code to alter the orientation of the image. If your build comes out sideways or upside-down, and you want to rotate the eye to compensate, look for this line in the code (Figure G), at the very end of the `setup` function.

To rotate the eye 90°, change `(0x76)` to `(0x77)` or `(0x75)`. Or to rotate it 180°, use `(0x66)`. I personally like this eye rotated 180° degrees to upside-down from the original image. I think It makes the eye look like it's up to something crafty, which is really what I'm looking for in my Eye of Newt.

MATERIALS

- **Teensy 3.1 or 3.2 microcontroller**
- **OLED 16-bit color display** Adafruit #1431
- **Photoresistor, CdS** Adafruit #161
- **LiPoly battery charger** Adafruit #2124
- **LiPoly battery, 500mAh** Adafruit #1578
- **Slide switch, SPDT** Adafruit #805
- **Resistor, 10kΩ**
- **Half-sphere cabochon, 1.5" acrylic**
- **Hookup wire, solid core** multiple colors
- **Silicone stranded wire** multiple colors
- **Reptile print or Halloween fabric**
- **Necklace cord or wide-mouth jar**

TOOLS

- **Soldering iron and accessories**
- **Hot glue gun**
- **Scissors**
- **Needle and thread**
- **Gaffer's tape or duct tape**

ERIN ST. BLAINE is a fashion and LED artist based in the San Francisco Bay Area.

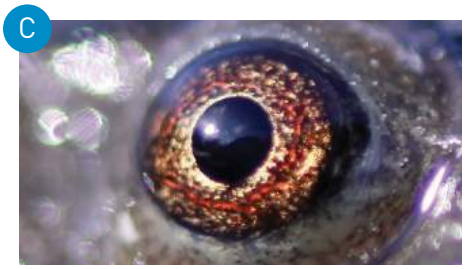
A

```
#include <SPI.h>
#include <Adafruit_GFX.h>     // Core graphics lib for Adafruit displays
#include "logo.h"             // For screen testing, OK to comment out
// Enable ONE of these #includes -- HUGE graphics tables for various eyes:
#include "defaultEye.h"       // Standard human-ish hazel eye
//#include "noScleraEye.h"      // Large iris, no sclera
//#include "dragonEye.h"        // Slit pupil fiery dragon/demon eye
//#include "goatEye.h"          // Horizontal pupil goat/Krampus eye
//#include "newtEye.h"          // Eye of newt
```

B

```
eyePins_t eyePins[] = {
  {  9,  0 }, // LEFT EYE display-select and wink pins
//{ 10,  2 }, // RIGHT EYE display-select and wink pins
};
```

C



D

E

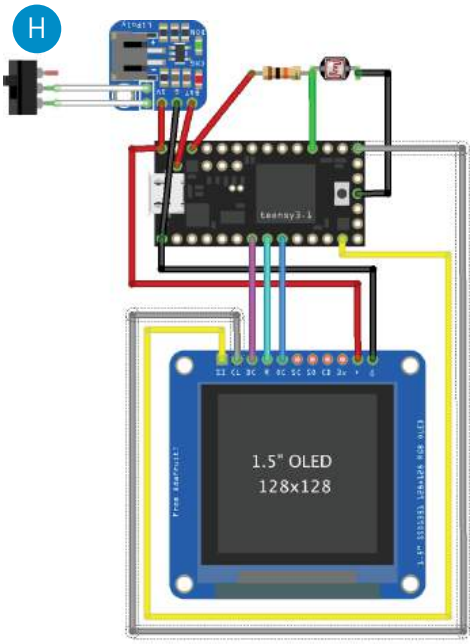
F

G

```
#else // OLED
  eye[0].display.writeCommand(SSD1351_CMD_SETREMAP);
  eye[0].display.writeData(0x76);
#endif
```

Supertrooper - Focusingonwildlife.com, Erin St. Blaine, Phil Burgess

H



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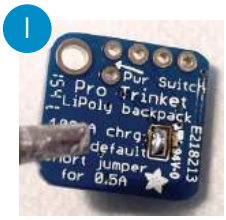

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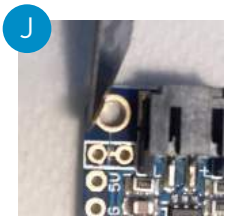

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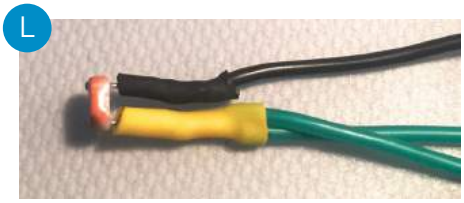

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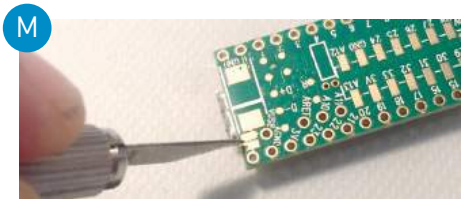

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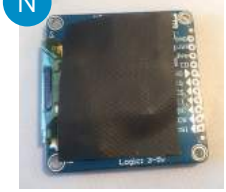

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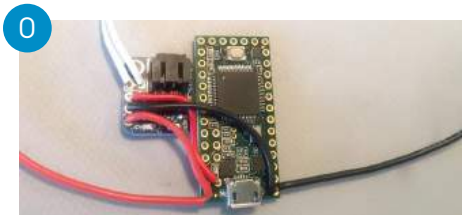

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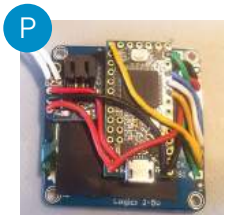

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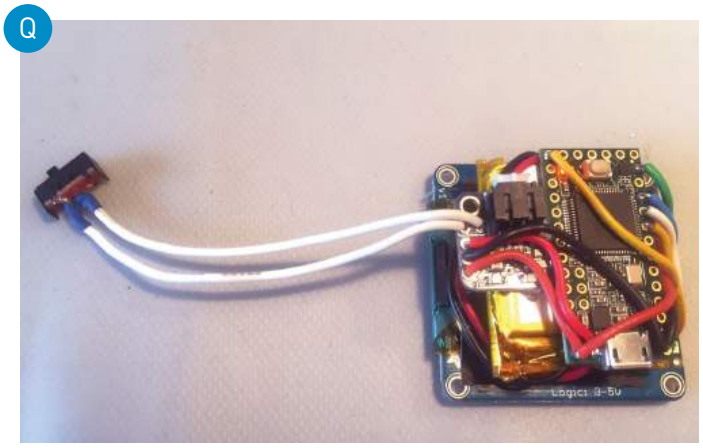

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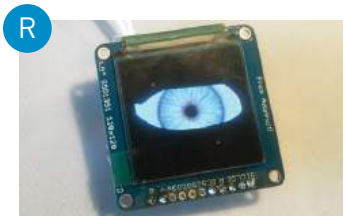

S

T

U

Erin St. Blaine

V

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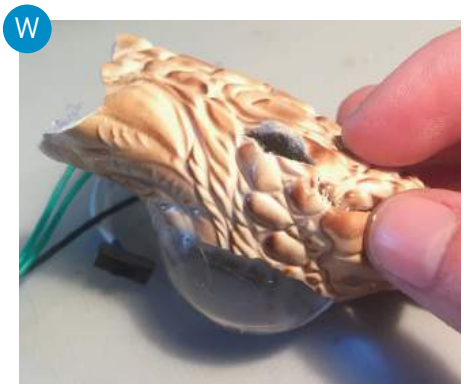


TROUBLESHOOTING

If you're having trouble, head over to the Uncanny Eyes guide and take a look at some of the troubleshooting ideas. If you see an eye on your display but it looks snowy and pixelated, check to be sure you've selected 72MHz as your CPU speed as noted before.

WIRING DIAGRAM

There are a lot of connections that need to be made (Figure H). Using a combination of solid core wire and stranded wire is the easiest way to get everything packed into as small a footprint as possible.

Color-coding is your friend here! Keep your power wires all red, and ground wires all black, and use a variety of colors for the other connections so you don't get confused. Write down the colors you used and the corresponding pins they connect with so you have a reference for soldering.

Teensy 3.1	OLED	Backpack Charger
Vin	+	BAT
G	G	G
USB		5V
7	DC	
8	Reset	
9	OC	
11	SI	
13	CL	
16		Resistor + Photocell
3.3V		Resistor
G		Photocell

ASSEMBLY

1. PREP YOUR CHARGER

Bridge the charge pad on the back with a blob of solder, to make your battery charge faster (Figure I).

Also cut the trace between the switch pads on the front to enable your on/off switch (Figure J).

2. PREP YOUR SWITCH

Trim the switch legs to about half their length. Solder 4" wires to the middle leg and one of the side legs, and cut off the other side leg. Secure the connections with heat-shrink tubing. Solder the two switch wires into the switch pads on the charger (Figure K).

3. PREP YOUR PHOTOCELL SENSOR

Trim your photocell's legs to about ⅓ of their length. Solder a stranded black wire to one leg, and two stranded colored wires to the other leg (the legs are interchangeable so it doesn't matter which is which). Cover each connection with heat-shrink (Figure L), then cover the whole photocell with larger heat-shrink, leaving only the top visible and uncovered.

4. PREP YOUR TEENSY AND DISPLAY

Cut the trace between the USB charging pads on the back of the Teensy (Figure M).

Place a large piece of thick tape (gaffer's tape or duct tape works great) over the back of the OLED display, carefully covering all the exposed components but leaving the solder hole labels visible (Figure N).

5. SOLDER POWER WIRES AND CHARGER

Using silicone stranded wire, solder two red wires into VIN and two black wires into G on your Teensy. We're using silicone stranded wire here because the solid core wires won't fit two-to-a-hole.

Set the charger next to the Teensy and solder a red solid core wire from Teensy's USB pin to the charger's 5V pin. Solder one of the stranded red wires to BAT and one of the stranded black wires to G (Figure O).

6. CONNECT PHOTOCELL AND DISPLAY

Solder various colors of solid core wires to the Teensy's pins 7, 8, 9, 11, and 13. You'll trim these to length later; for now just be sure they're at least a couple inches long.

Trim one leg of your resistor down and solder it into the 3.3V pin on the Teensy. Solder the other leg to one of the colored wires coming from your photocell sensor. Cover the whole resistor with heat-shrink.

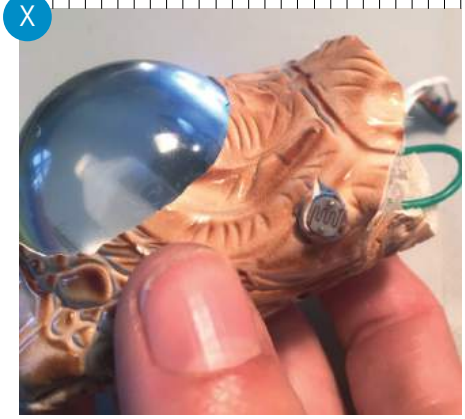
Solder the other colored wire from the photocell into Teensy's pin 16, and solder the photocell's black wire into the GND pin next to the Teensy's reset button.

Place the Teensy and charger in line with the back of the OLED display as shown in Figure P. Carefully trim and solder all the remaining wires to the OLED display.

Plug your battery in and slide it between the OLED display and the rest of the components. Wind the wire around and bend the solid core wires until you have a tidy package (Figure Q). Secure everything in place with a few judicious blobs of hot glue.

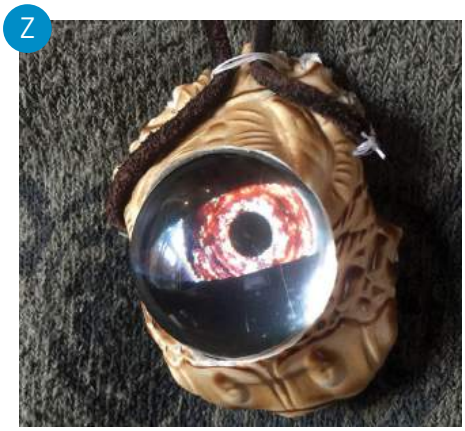
Flip your switch on and watch your eye dance around (Figure R). Cover the photocell to watch the pupil dilate!

X



Y

Z



AA

Find this project online at learn.adafruit.com/eye-of-newt.

7. MAKE THE CASE

Cut a small piece of fabric about 8"× 8". Place your cabochon in the center and trace around it on the wrong side of the fabric. Cut a hole for the cabochon that's a little smaller than your mark so the cabochon won't fall through (Figure S).

Fold your fabric in half around your electronic eye and mark where it meets itself. Sew the raw edges together with the right sides facing inward (Figure T). Flatten the fabric so the hole is on top and the seam is at the center back. Stitch a curved edge about 1" below the hole (Figure U). Make sure the electronics fit nicely inside.

Place your cabochon into the hole, face down (so you're looking at the flat side). Run a bead of glue all around the edges to hold it securely in place (Figure V). Turn your case right side out and gently slide the electronics inside with the switch and photocell coming out the open top. With a utility knife, make a small slit above the USB port (Figure W). Make another hole for the photocell sensor to poke through (Figure X). Sew up the top of the case with a needle and thread, leaving the on/off switch accessible (Figure Y). I colored my on/off switch with a paint pen so it blends in better with my case.

Finish up by attaching a necklace cord (Figure Z), or leave it as-is and keep it safe inside a potion jar (Figure AA). Remember that the OLED screen is really delicate, so don't try and squeeze it into a jar that's a tight fit — you can break the screen if you squeeze it too hard.

TOIL AND TROUBLE!

Charge it up by plugging in a USB cable — the indicator light on the charger will turn green when it's fully charged. Now you're ready to cast your spells.

LOST KNOWLEDGE

The "Discreet Companion" Ladies' Raygun

A pocket butane raygun for steampunky cosplay. [BY MOLLY FRIEDRICH]

First invented in 1885 for use by the daring ladies of the Cloud Frontier, the Discreet Companion has been a staple of purses and garter belts ever since.

Torch lighters are handy, cheap, and easy to find. They come in a wide variety of shapes and styles, so there's room for customizing to your personal taste.

I normally modify mine with antique parts, but here I chose parts that you can get in most hardware and home stores. The finished raygun works well as a prop; simply pull the "trigger," and an inch or so of fire shoots out the barrel!

This project uses a $10 Dodo brand lighter. If you use a different lighter, you may need to change the size of the pattern to accommodate it. You need to use a lighter that, when installed into the barrel of the raygun, will shoot forward.

Some point in other directions — obviously, avoid these, unless you specifically want a booby-trapped gun!

You might try a different ornate coat hook for a different-looking handle. The handle can also be mounted forward or backward.

The lamp parts are easy to customize — you can change the look just by using different finials and other decorative elements — and the design on the front of the barrel can be almost any shape you want.

This project is fairly easy to do, takes a few hours, and costs about $30–$40 in parts (less if you have some stuff already on hand).

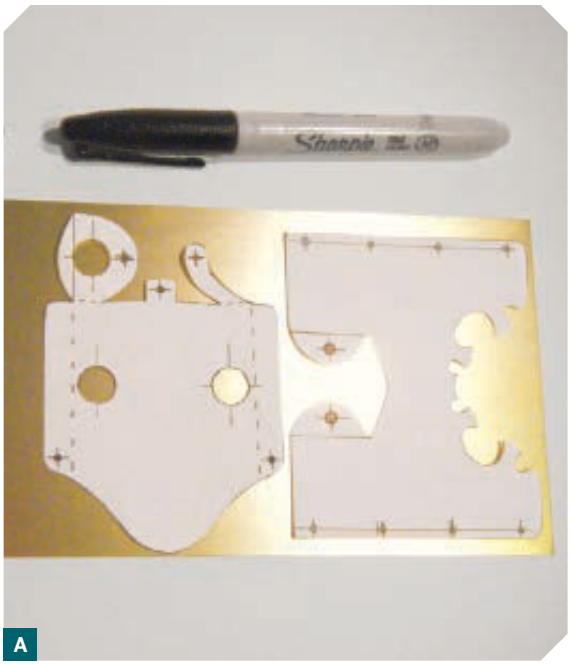
In this dimension, Molly "Porkshanks" Friedrich is a freelance costume, prop, and jewelry designer. She's also an infamous pan-dimensional smuggler and freelance artist.

Photograph by John Keately

Photography by John Keately (left) and Molly Friedrich

Torch-style cigar lighter
Ornate stamped brass lamp check rings, 1⅛" diameter (2)
Brass lamp washers with fixture seat and ⅞" opening (2)
Steel 1¼" washers (2)
1" lamp knob finial
Brass ¾" knurled locknuts (2)
Brass 9⁄16" bracket caps (2)
Nickel-finish 1¼" washer
Brass ⅛F hex locknuts (2)
Brass ⅜" to ⅛IPS reducer
⅛IPS lamp nipples (2): 1" long and 2" long
4-40×⅜" slotted round machine bolts (2)
4-40 nuts (4)
Tiny 2-part decorating rivets (5)
Hall tree hook B&M Hardware part #B&M1901
Brass sheet 0.010"×4"×10"
Patterns (2) Download at makezine.com/17/raygun.

Scissors
Marker
Small flathead screwdriver
Needlenose pliers
Metal snips
Hole punch
Hammer
Scrap wood
Metal rod or pole less than ¾" diameter
Rivet setting tool



A

1. Build the body.

1a. Print the 2 patterns, cut them out, and trace them onto the brass sheet with a marker. Be sure to mark carefully the dashed lines (where the metal folds) and all holes (Figure A).

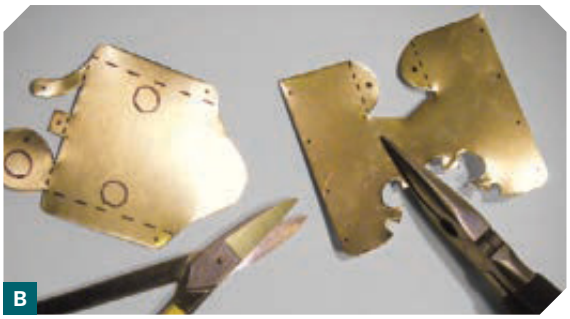
1b. Use a pair of metal snips to cut out the shapes. Take your time. Don't worry if the edges bend a little; this is normal. When you're done cutting, use your pliers to flatten the edges out again (Figure B).

CAUTION: Be careful not to cut yourself when cutting and bending sheet metal. I never use gloves, and my poor fingers hate me for it. Don't be like me!

1c. Set the metal shapes on a scrap of wood and use a hammer and hole punch to punch holes where marked. For larger holes, do a few punches and then cut the hole with snips. If the metal deforms as you cut, use your pliers to flatten it out afterward (Figure C).

1d. Bend both pieces on the dashed lines. Bend the rounded tabs away from the marks on the barrel piece (Figure D), and bend the long sides and the back in toward the marks on the body piece.

1e. Bend both parts over to round them into tubular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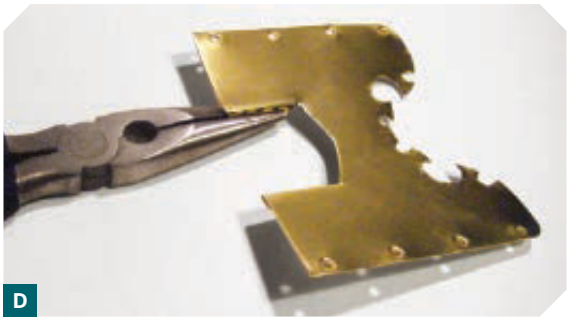
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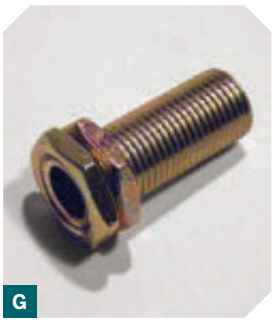
E


F


G


H

shapes as shown (Figure E). Insert the rivets into the holes of the matched-up ends of the barrel piece. Don't forget the single rivet that goes through 3 holes on the backside of the body piece.

To pound the rivets into the barrel piece, you'll need a metal rod. Slip the piece over the rod and hammer the rivets. Use the rivet setting tool to reach the inside of the single rivet on the body piece.

1f. Slide the open end of the body piece over the end of the barrel at the rounded tabs. The holes from the folded sides of the body should line up with the holes in the rounded tabs on the barrel. From the inside, insert a 4-40×⅜" slotted round machine bolt through each set of lined-up holes (Figure F).

2. Add the back.

2a. Put the hex nuts on one end of the 1" lamp nipple, tightening them against each other so they don't slide around (Figure G).

2b. Slide the other end of the nipple through the large hole on the back of the body (Figure H). Add the ⅜" to ⅛IPS reducer, the nickel-finish washer, and the 1" lamp knob finial (Figure I). The center of my washer was too small for the nipple, so I used the metal snips to cut the hole a little larger.

3. Attach the handle.

3a. This is the trickiest part and takes patience.


I


J


K


L


M


N

Pressing in on the sides of the gun body at the bolts (friction will help keep them in place), navigate the bolts into the holes on the base of the B&M hall tree hook, aka raygun handle (Figure J). If you have a hard time getting the bolt to go through the holes, use a small screwdriver to push it down and guide it in.

3b. Once you have enough of the bolt showing through, slide a nut on and tighten it down with pliers (Figure K). Do this for both sides, then add a second nut to each bolt to lock everything down.

4. Add finishing touches.

4a. Slide the 2" lamp nipple through the side holes so that equal amounts stick out on each side (Figure L).

Add to each side, in order, 1 brass lamp washer with fixture seat and ⅞" opening, 1 steel 1¼" washer, 1 brass lamp 1⅛" check ring, 1 brass ¾" knurled locknut, and 1 brass 9⁄16" bracket cap (Figure M).

4b. Slide the lighter into place. You may have to press in the sides of the gun barrel slightly to fit. Friction should hold it; in fact, I usually have a hard time pulling the lighter out to refill it. If it gets stuck, use a screwdriver to push on it from the back, where the gun barrel drops down near the handle base (Figure N).

5. Fire away.

Don't smoke, kids! Use your raygun to light devotional incense, airship lanterns, or cartoon dynamite only!

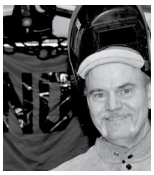
Skill Builder

TIPS AND TRICKS TO HELP EXPERTS AND AMATEURS ALIKE

Written by Tim Deagan

HOW TO Hand Sew Leather

This basic technique will propel you toward custom tool coverings, bags, apparel, and more



TIM DEAGAN (@TimDeagan) casts, prints, screens, welds, brazes, bends, screws, glues, nails, and dreams in his Austin, Texas shop. A career troubleshooter, he designs, writes, and debugs code to pay the bills. He's the author of *Make: Fire*, and has written for *Make:*, *Nuts & Volts*, Lotus Notes Advisor, and Database Advisor.

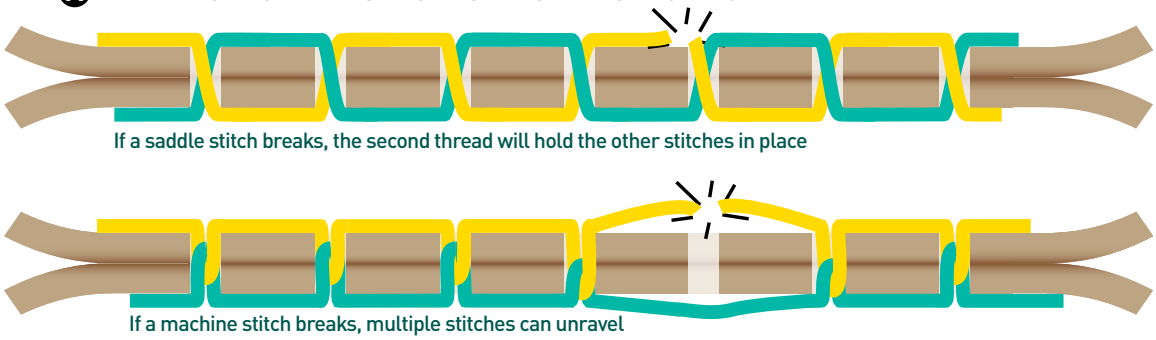
THOUGH ITS HISTORY DATES BACK TO THE DAWN OF CIVILIZATION, leatherworking remains an enjoyable and useful skill even in the age of 3D printers. And while you can spend a lifetime learning the deeper intricacies of leather, the basics are easy enough for anyone to pick up. Among the most useful of these skills is the ability to sew pieces of leather together. The process is similar to sewing cloth, but has some significant differences. In this skill builder, we'll learn how to hand sew leather using the saddle stitch.

Hand sewing leather may seem daunting, but it's inexpensive, very strong, and less work than you might imagine. The saddle stitch is actually more durable than a machine stitch. When a machine stitch breaks, the entire piece will quickly unravel. When a saddle stitch breaks, the threads bind each other in place (Figure A).

Stitching needles are heavier, longer, duller, and have a larger eye than regular sewing needles. As opposed to sewing cloth, the needle is not intended to create its own hole. A hole is punched through the leather by an awl or chisel, then the needle is pushed through. We'll use two needles, one on each end of waxed thread. This thread is much heavier and stronger than cloth thread and is typically made from multiple cords of strong linen or synthetic material. A small lump of beeswax will help bind the thread (Figure B).

Hep Svadja

A THE MANUAL SADDLE STITCH VS. MACHINE STITCHING



If a saddle stitch breaks, the second thread will hold the other stitches in place

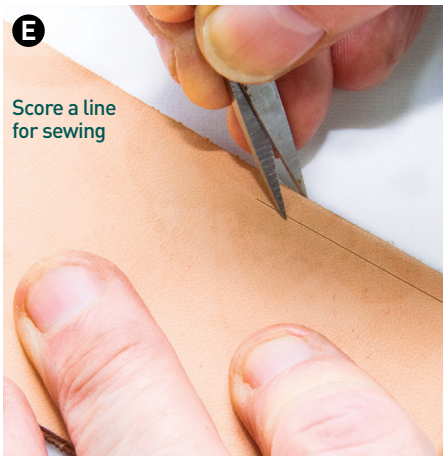
If a machine stitch breaks, multiple stitches can unravel

B Basic hand sewing leather tools

C Piercing the thread with the needle

D Pull the thread to tighten the splice

E Score a line for sewing



F Punching the holes

G My homemade "stitching pony," a smaller version of a traditional stitching horse that holds leather while you sew

Cut some thread to the length of your arm span. For big projects, double that. Pass the end of the thread through the eye of the needle, then pierce the tip through the thread about 3" from the end (Figure **C**). Personally, I always pierce the thread twice.

Slide the thread down the needle until it passes the eye, then draw it tight (Figure **D**). Rub the beeswax along the splice and roll it tight between your fingers. Perform the same operations on the other end of the thread with the second needle.

Now let's prepare the leather. We need to score a line that is the same distance from the edge of the leather as the thickness of the two pieces of leather being sewn. There are fancy tools for doing this, but you can use scissors as a makeshift compass cutter to accomplish the same thing (Figure **E**).

The distance between the holes varies with the intended use, thickness of thread, and weight of leather. If you're using an awl, an overstitch wheel is the best way to mark the locations. While using an awl is old school cool, chisel forks have become much more popular. Place the two pieces of leather together in the position you want to sew them. Set them on a smooth work surface padded with some thick scrap leather that you don't mind damaging.

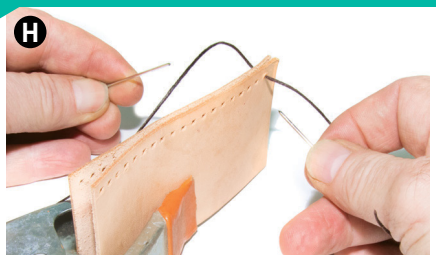
Hold the fork along the marked line and use a soft-headed hammer to punch it through the leather. Drive the fork all the way through the two pieces being punched. Pull the fork out, set the first prong in the last hole and punch the next section (Figure **F**). Continue until holes are punched along the length to be sewn.

You can also hold the leather in a stitching horse, between your knees, in a soft-jawed vise, or in any manner that will leave your hands free (Figure **G**), because two needles require two hands.

Pass one of the needles through the hole where you want to start and pull it until

Tim Deagan

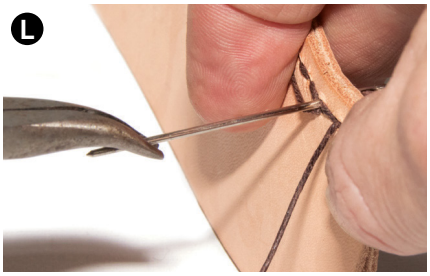
Skill Builder How to Hand Sew Leather


Ready to start sewing


Place the front needle in the hole


Pull the stitch tight


Backstitch to finish off


Pull a needle through tight stitches with pliers


Extreme close-up of the stitches

GOING FURTHER

What we've covered is only the most basic of stitches. If you'd like to learn more, the master reference is Al Stohlman's *The Art of Hand Sewing Leather*. This excellent instruction book has taught tens of thousands of leatherworkers basic and advanced techniques.

the workpiece is in the middle of the thread (Figure H).

Take the needle that will be on the back of your work and pass it back through the next hole. We will stitch toward ourselves. Pull two inches of thread through the hole. Take the front needle and push the tip just through the hole in front of the thread that's coming through. We always place the front needle in front of the thread from the back needle (Figure I).

Before you pull the front needle through the hole, we need to make sure it didn't pierce the back thread. If that happens, the stitch will have to be cut and you start over (or learn the advanced skill of dealing with a pierced thread). We can avoid this by pulling the back thread back through the hole as we push the front needle into the hole. When the front needle is almost all the way through we can stop pulling the back thread. Then we take a needle in each hand and pull evenly until the stitch tightens (Figure J). Note that the needles alternate front to back on each stitch.

Continue this sequence along the row of holes until you come to the end. To finish and secure the threads, we'll backstitch for two holes. This means that we will change direction and stitch over the last two stitches (Figure K).

The needles will be harder to get through the holes that already have thread in them. I generally end up using needlenose pliers to pull the needle through (Figure L). Be careful doing this since it may weaken or break the needle. You can avoid this by carefully pulling straight through and not putting any side force on the needle. Breaking off a needle can be dealt with if there's enough line to thread a new needle and keep going. Otherwise you'll have to backstitch as much as you can with the other needle and hope it holds.

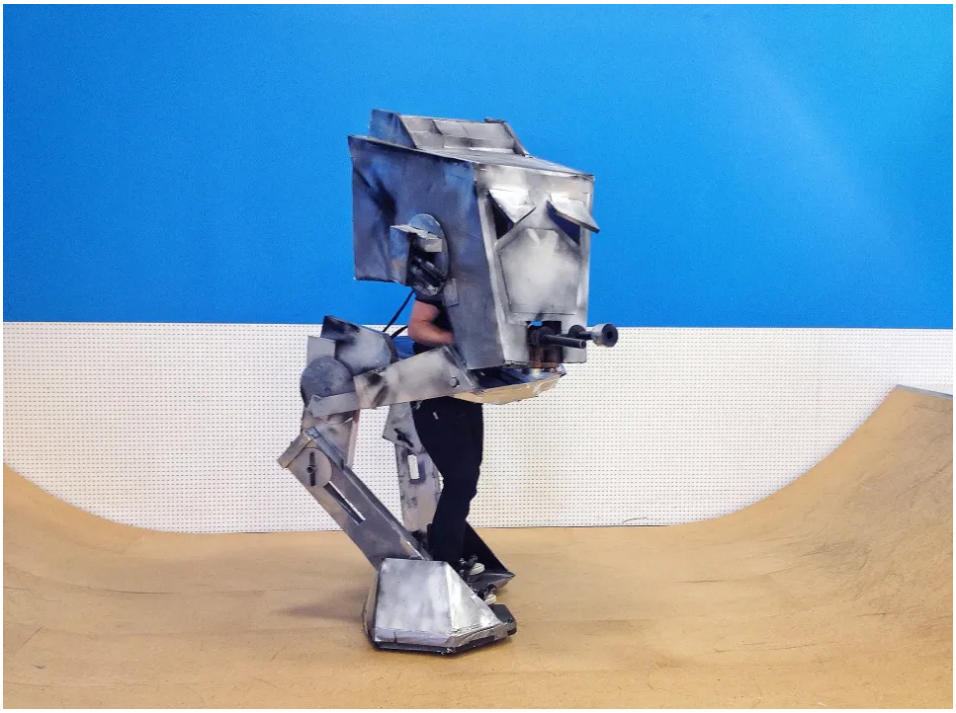
Once finished, use small scissors or a utility knife to cut the remaining threads as close to the leather as possible. Many leatherworkers use a special tool called a stitching groover to gouge a shallow trough along the line of holes and, when finished sewing, use a hammer to tap the stitches down into the trough. This tucks them out of harm's way and makes them last longer.

With a little practice, hand sewing becomes a fast, easy, and fun way to make anything from a wallet to a saddle. Give it a try and discover a whole new world of leatherworking!

Tim Deagan

Building a Fully Animated AT-ST costume

Written by Joseph Bowers • makezine.com/projects/building-a-fully-animated-at-st-costume



TIME REQUIRED: 38 Hours

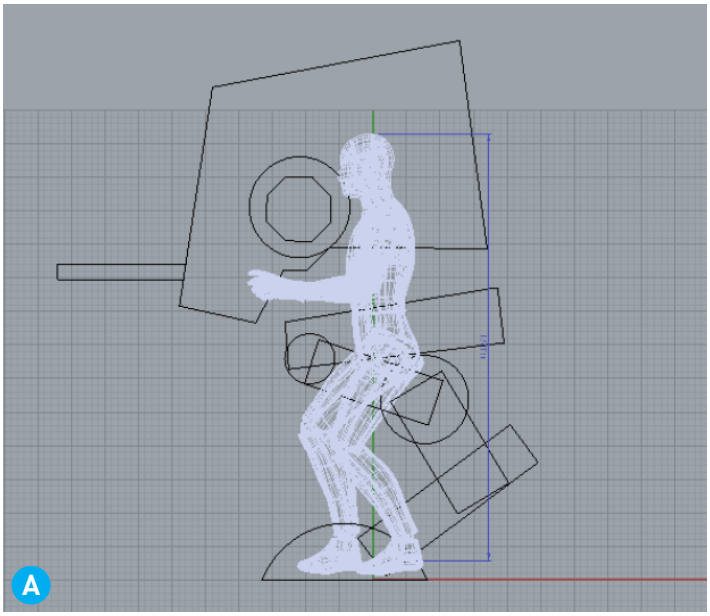
DIFFICULTY: Easy

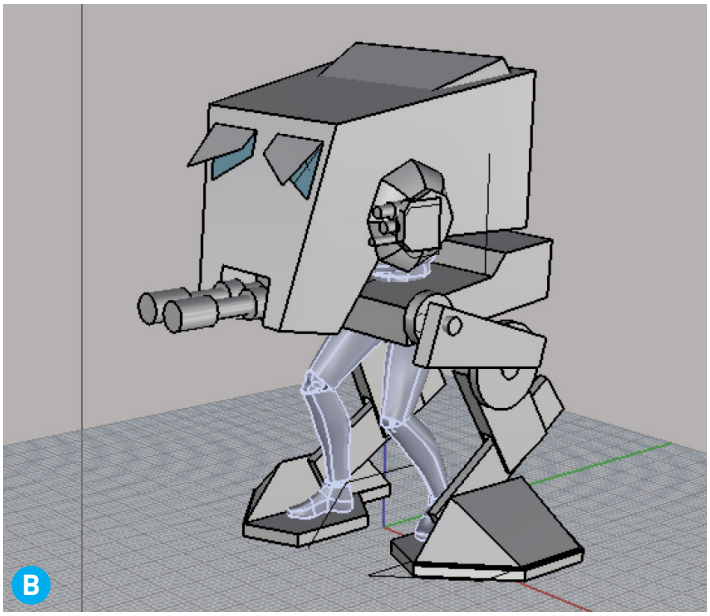
MATERIALS

- Insulation Foam
- Printer Paper
- Wheatpaste
- PVC pipe
- Cardboard
- Wooden Dowels
- Duct Tape
- Spraypaint
- Wood Scraps

TOOLS

- **Utility Knife** The ones that have retractable blades. That way you can extend the blade to cut the thickness of the insulation foam.
- **Yard Stick** For measuring, and as a straight edge
- **CAD**





Last year I built a 7-foot tall, fully animated, chicken walker costume using mainly just insulation foam, spray paint, and printer paper.

DESIGN

After doodling a little bit, I created the basic form out of Rhino 3D (but one could just as easily used Google SketchUp) and used the CAD model as a guide for construction (Figure A). I decided almost immediately that I didn't want to do a completely loyal scaling down of the AT-ST, but instead wanted to do a miniature interpretation of the character. This meant I needed to tweak and take some liberties with the proportions and design. Using CAD was invaluable in helping me explore the form. The result ended up being what my wife called "a cute little baby one." Not my favorite critique, but also not entirely inaccurate.

CONSTRUCTION

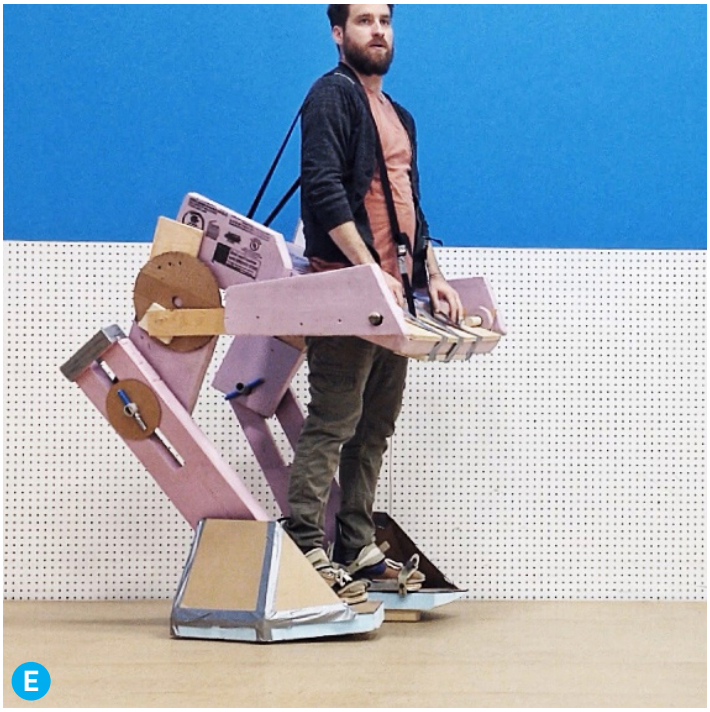
Using the CAD model as a visual reference, and a general guide for measurements, I used 2"-thick pieces of insulation foam to create the basic frame (Figure B). Everything was done more or less by eye from this point. There was no need to build it directly from the CAD plans.


C

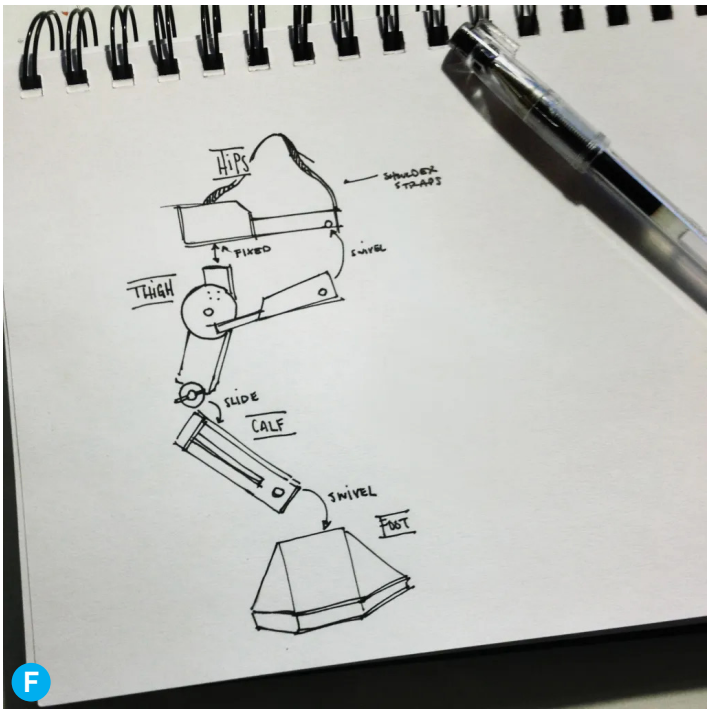

D

I started with the feet and cut out the rhombus-shaped footprints from insulation foam using a retractable utility blade. I then shrouded those foam "soles" using cardboard and duct tape. For the mechanical joints on the limbs, you can see I used scrap PVC pipe, cardboard circles, and little wooden dowels as a kind of washer/bolt connection system (Figure C). I also used snowboard bindings, (acquired at a local thrift store for $3) for the feet straps. Snowboard bindings come with holes in the bottom that work well for drilling into the base of the feet. You'll also note that I eventually put 2×4s on the bottom to lift the feet off the ground and give me a better range of motion as well as make the soles more durable (Figure D).

In Figure E you can see that while foam made up most of the costume, there are certain stress points that needed to be reinforced with wooden blocks. The way I discovered each stress point was by putting the thing together, walking around, and seeing what broke first. At which point, I put the thing back together, replacing the broken foam with wood pieces. This process was repeated more times than I care to admit. But it was effective. Just a few blocks in the right places and the thing was plenty sturdy for vigorous travel.


E

It took lots of iteration to get the "animation" of the thing to work just right. But this part really was the most fun (Figure F). There's really nothing like making something that looks like it could be alive. At one point I was so convinced that I needed to make a career of this that I did a quick Craigslist search looking for job postings on making really, really tall, wearable puppets. Nothing yet, but I remain optimistic.



F

To get that distinct walk down just right, I would put together the limb assembly and take video of myself walking around a bit. I then watched the video and decided if I needed to move things around a little here, or loosen things up there. Mostly it came down to the lengths, angles, and joints. You can see by my diagram where things generally went as far as swivel joints, slide joints, or fixed points.

The hips and thighs need to be fixed to each other, I found. And the calf needs to slide freely at the knee, and swivel at the ankle. It's also important to mention that the "hips" should be lose around the waist of the wearer. You want a lot of movement in the hips to give the walk some character.

The head I made using the follow steps:

- I laid some 1" insulation foam on the ground and, using wheat paste, plastered it with a bunch of 8.5×11 sheets of printer paper. This would allow me to spray paint the costume, as foam erodes when it makes contact with aerosol.
- I drew the pieces I was going to cut out onto the paper. (If you want to get tricky you can actually print the guides out "poster-style" from the CAD model.)
- I cut out the 4 panels of the head using a utility knife. And I cut out the eyes as well.
- I taped the 4 panels together. And taped back on the eye-lids.
- On the underside you can see that I mounted a piece of wood as a crossbeam under the jaw. This I did to create strength and also give my arms something to hold onto while in the costume.
- Using that same crossbeam, I mounted some PVC pipes as the blasters.

We now have a fully animated, naked, chicken walker (Figure G).

PAINTING/FINISHING

When the the kinetics were pegged down just right, I dissembled the thing and paneled all exposed foam with paper using wheat paste. I then painted the paneled pieces with metallic, gray, and black spray paint to get the distressed, battle-worn aesthetic (Figure H). The paper panels not only made it easy to paint and protected the foam, but the seams of the paper, which I made sure were a brick pattern, naturally made the costume look like it was crafted out of metal sheets. I found it important to carefully alternate between glossy and matte spray paints to get the desired finish.

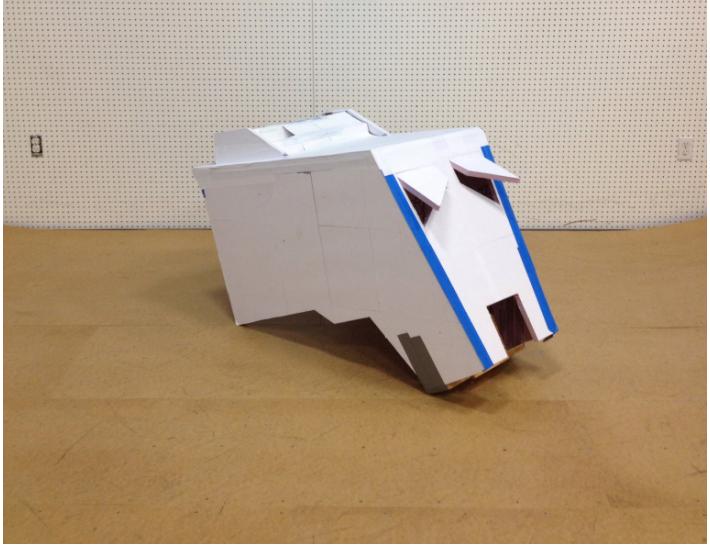
This is also when I added more guns and small pieces of foam to simulate components and other details.

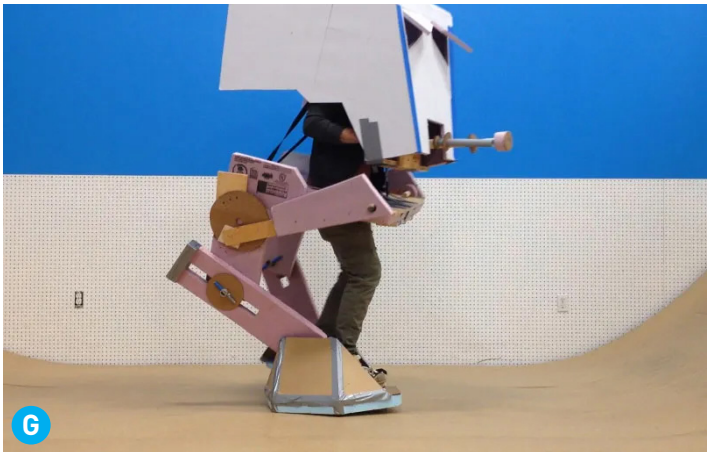
BLAST-HOLES TECHNIQUE

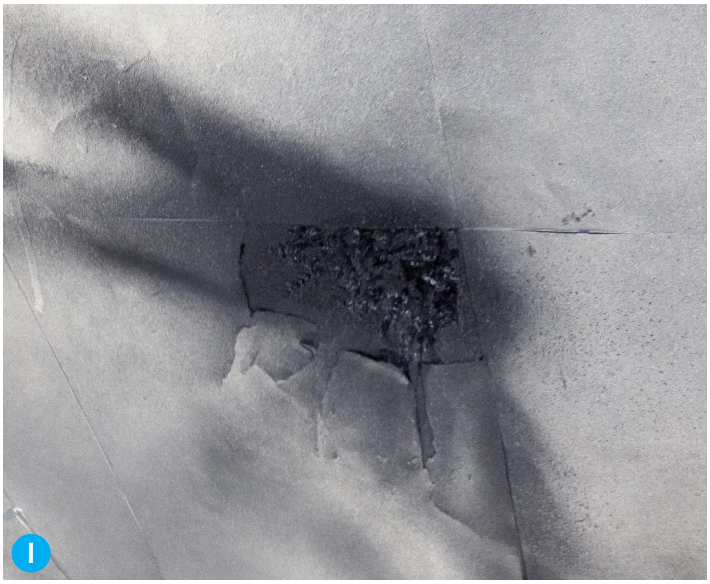
Since the insulation foam erodes on contact with the aerosol, I used that to my advantage to make "blast holes." I just ripped some paper away and sprayed directly onto the foam. The bubbling and eating-away of the foam looked remarkably like what I would expect a laser blast to look like. If it didn't eat away enough, I chipped away some pieces of foam and painted again (Figure I).

COST/TIME

The materials were extremely cheap for a project like this. I used pink insulation foam, normal printer paper, and spray paint. I used a lot of scrap wood I had handy, and got some cardboard and PVC pipe from a dumpster. The only other major expense included the $3 thrift-store snowboard bindings. It took me roughly a week to design and build. But I'm pretty happy with the results.







Sculpt Demon Horns from Foam and Paper Towels

Learn how to make bendable horns, any size, for Halloween costumes or cosplay

Written by Breanna Cooke • makezine.com/projects/sculpt-demon-horns-from-foam-and-paper-towels

TIME REQUIRED: 38 Hours

DIFFICULTY: Easy

MATERIALS

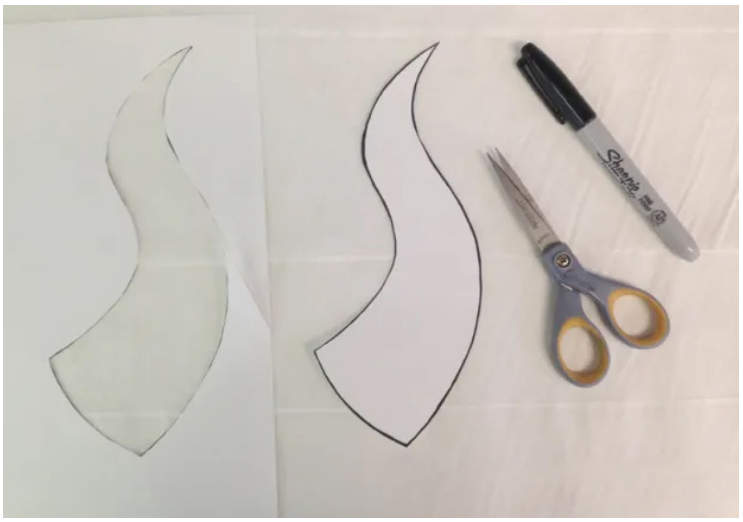
- **Paper, 8.5"×11"**
- **Polyurethane foam, aka upholstery foam. Flexible, 1'×1'**
- **Hot glue**
- **Liquid latex or mask latex** Available at costume, theatre, or mold-making supply stores.
- **Paper towels (10) or tissue paper**
- **Plastic hairband**
- **Acrylic paints** Available at craft stores. I used black, tan, and white.

TOOLS

- **Marker**
- **Scissors, small**
- **Box cutter knife**
- **Hot glue gun**
- **Paint brushes, 2 medium, 1 small**

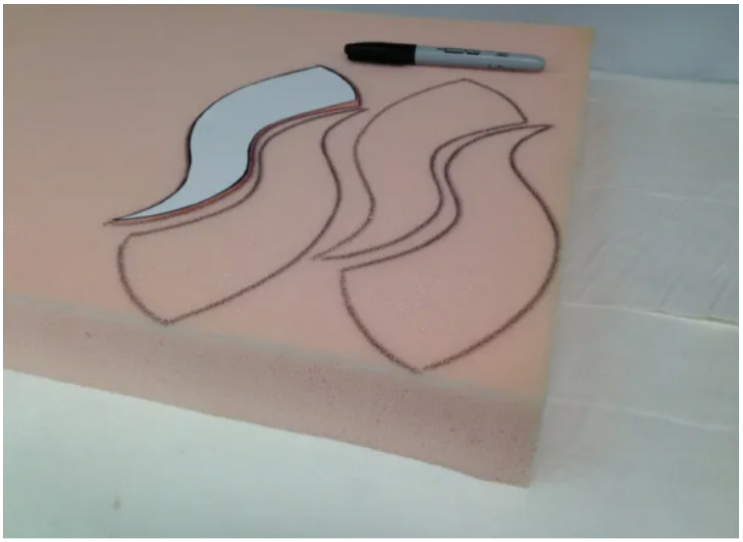
BREANNA COOKE is an artist with a passion for bringing creatures to life, both on paper and in fantastical costumes. Originally from Toronto, Canada, Breanna has been creating all her life. She currently lives in Dallas, Texas, where she does graphic design, body painting, and creates her creature costumes. Check out more of her work at www.breannacooke.com

These horns are easy to modify to fit the shape and size of your costume character. You can also modify the texture to make them as realistic or as fantastical as you need. I'll show you how to carve the horns from flexible foam then texture them with a liquid-latex technique that looks great.



Step 1: Make a paper pattern

- Draw your horn shape on a piece of paper and cut it out.

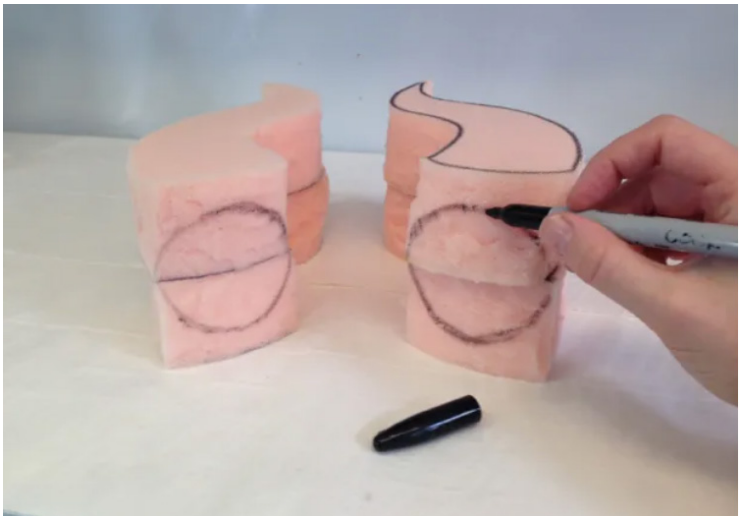


Step 2: Trace horn onto foam and cut it out

- Sculpt Demon Horns from Foam and Paper TowelsSculpt Demon Horns from Foam and Paper Towels
- Trace your horn pattern onto the foam with a marker and cut it out with scissors or a box cutter knife.
- If your foam is not thick enough to use as one layer, cut out duplicate horn shapes so you can glue them together to make a thicker piece of foam.

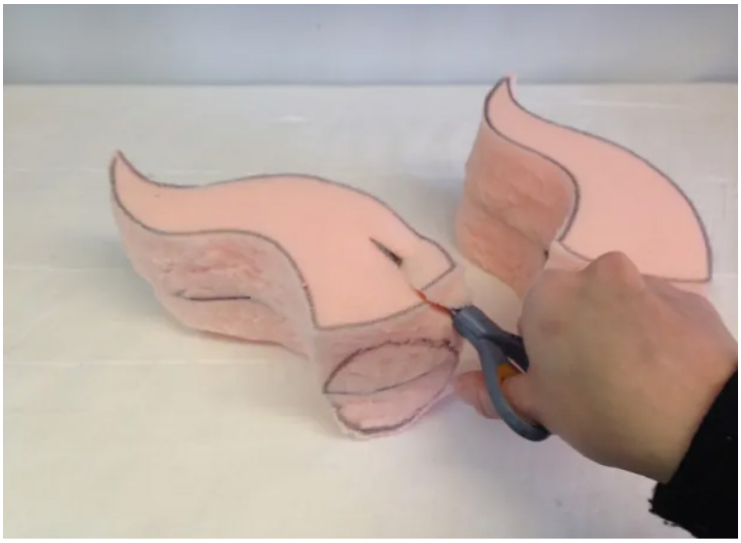
Step 3: Glue foam layers together

- Using hot glue, liquid latex, or contact cement, glue the 2 layers together. Here I used liquid latex. Let it dry before working on shaping the horns.



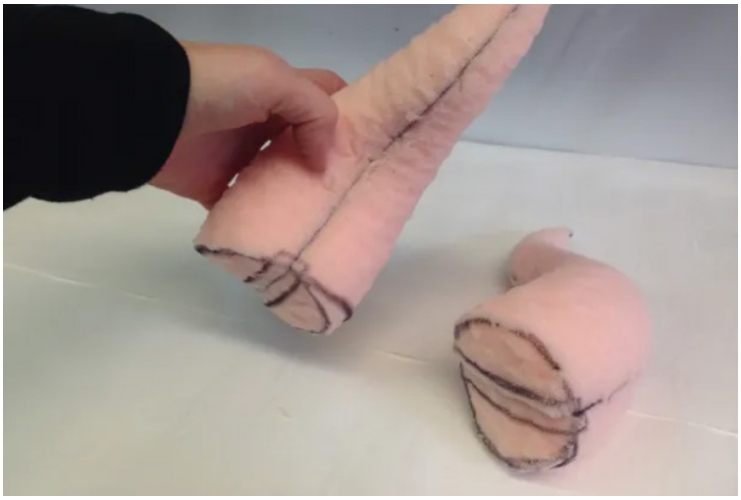
Step 4: Draw guidelines

- With the marker, draw the shape of the base of the horn onto the bottom of the foam.



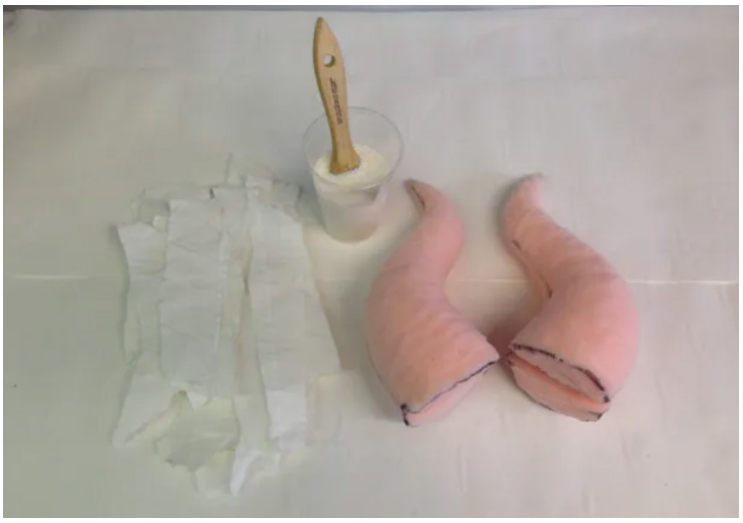
Step 5: Refine the horn shape with scissors

- Using scissors or a box cutter, slowly trim off small pieces of foam to shape the horn. Don't worry about making it perfectly smooth.
- As you work on the second horn, compare it to the first one to be sure they are the same shape.



Step 6: Final trimming

- With the marker, draw the outline for the trench on the base of the horn. Then cut out the trench using a box cutter. It should be deep enough to fit the hairband in so that the horn will sit flush against your head.
- If you'd like your horns to tilt backwards, trim the base of the horn at an angle.



Step 7: Covering the foam horns

- Tear apart strips of paper towel that are long enough to wrap around the horns. Brush a layer of liquid latex onto the foam, apply the paper towel to the latex, then brush on another layer of latex to coat the paper towel.
- To create ridges on the horns, roll the edge of the paper towel before applying it to the horn.

Step 8: Add paint

- Be sure the horns are dry before you paint them. When the latex is dry it might still be tacky, so powdering it with baby powder will remove the tackiness.
- The horns can be painted with regular acrylic paints. Start with a light colored base coat, then build up more dark colors.
- To achieve the rough gradient effect, us a dry-brushing technique, where you put a bit of paint on your brush and let it become slightly dry as you apply it to the horn.

Step 9: Glue to hairband

- Attach the horns to the hairband with hot glue or contact cement. Fill the trench with glue, then push the hairband into place. Don't worry if there is a slight gap at the end of the trench. As long as the horns are securely attached, they'll be fine.

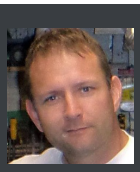
CONCLUSION

The horns can be modified in multiple ways and can be attached to a helmet or headpiece. To make the hairband even more comfortable, wrap the plastic with fabric or ribbon. For added security, especially for a performance, glue small hair combs to the base of the horns and/or sides of the hairband.

Construct a Fearsome Battle Axe Prop from MDF and PVC

Written by Shawn Thorsson • makezine.com/projects/halloween-2016-battle-axe-prop/

TIME REQUIRED: 16 Hours
DIFFICULTY: Moderate



SHAWN THORSSON
At a very young age, Shawn learned that the surest way to get the coolest toys was to make them yourselves. Now he makes costumes and props for films, promotional uses, and the occasional private commission. You can read more about his projects and scattered other adventures in his blog.

This project is an excerpt from Make: Props and Costume Armor. Learn how to paint, finish, and replicate this project, and discover step-by-step projects for more props and armor. Make: Props and Costume Armor *is available on Maker Shed and other retailers. makershed.com/make-props*

We can call her "Ermahgerd, Warrior Maiden of the Wolf Clan and her great-axe Hedwak."

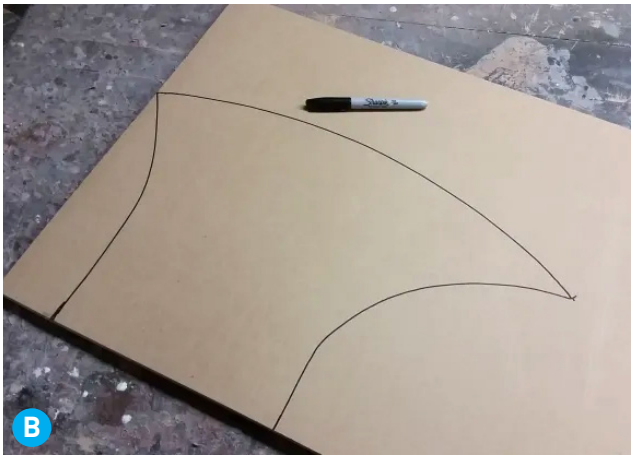
A

CAUTION: In this tutorial we'll be using medium-density fiberboard, or MDF. The adhesive used to bind MDF together contains formaldehyde and all sorts of other carcinogenic compounds. Wear a respirator and work in a well-ventilated area.

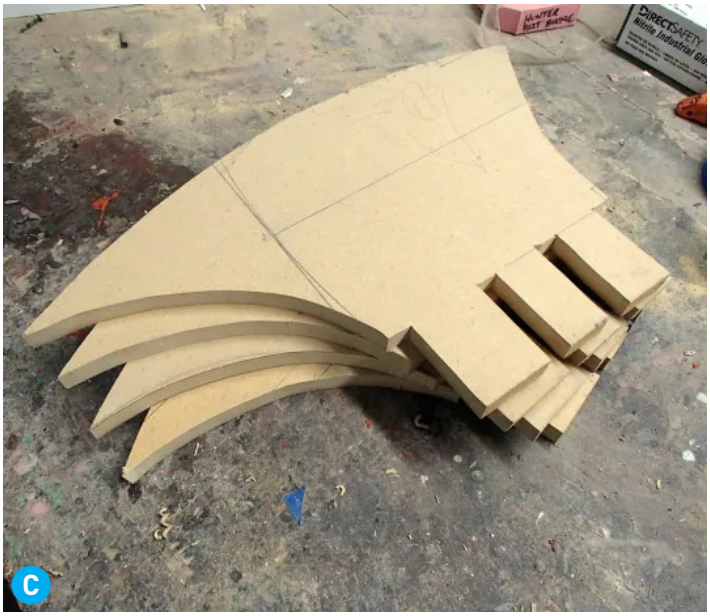
If your workshop is stocked with anything, at the very least you probably have some combination of flat stock. By stacking multiple layers of flat materials, often in different thicknesses, you can make all manner of things. It's only a matter of identifying the different layers needed and getting started.

Now, for an example of how this process can be applied to something rather impressive, take a look at the as-yet-unnamed warrior woman in Figure A above.

To give her weapon the right sense of thickness, the blade will be made out of two layers of ¾" (about 19mm) MDF. The whole process begins with drawing out the profile of half of the double-headed blade onto a piece of MDF, as shown in Figure B.



B



Then shalt thou count to four. No more. No less.

These widgets will make a lot more sense in a moment.

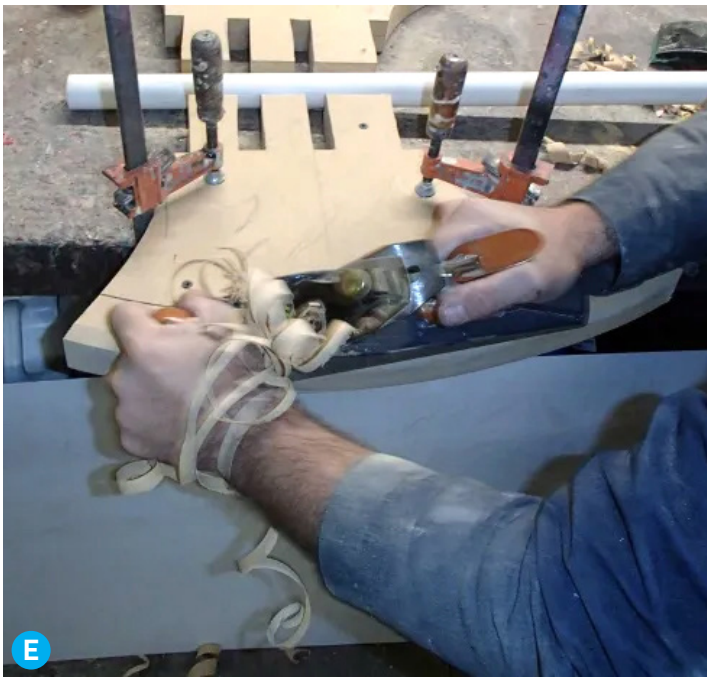
Then, using a jigsaw, cut out four copies of this profile (Figure C).

Since the whole head of the axe will have to fit onto a shaft of some sort, the blade halves should be notched in order to fit cross pieces to tie them all together. The four matching cross pieces can be seen in Figure D.

At this point, the two halves of each side of the blade need to be glued together. In order to keep everything from shifting around while the glue dries, clamp them together with spring clamps, or simply screw them together with some drywall screws.

Once the glue is completely dry, it's time to put an edge on the blade. This can be done by grinding it off with a coarse file, whittling it down with a sharp knife, sanding it off with a belt sander or flap-wheel grinder, or simply clamping the work piece to the edge of the bench and shaping the edge with a jack plane (Figure E). It's really just a question of the tools you have at your disposal.

Once the rough shape of the two blades has been made, the edge can be shaped a little more with some 80-grit sandpaper on a sanding block (Figure F).



Cutting the edge of the blade with a jack plane

Fine-tuning the blade shape with a sanding block

The rough-shaped blades

The hole saw quickly makes Swiss cheese out of the MDF axe blade.

The blades propped up on some scraps of MDF so they'll stay straight

Keeping the handle in place makes sure that the holes will line up properly.

At this point, the blades are about the right shape, as shown in Figure G.

Unfortunately, they're still a little on the heavy side. This can be mitigated by cutting big chunks out of the middle of the blade with a hole saw, as shown in Figure H. Just like in aircraft or ship construction, these interior holes (called lightening holes) will reduce the weight of the finished piece without compromising the strength.

No hole saw? Drilling a couple of starting holes will make it possible to cut big chunks out of the middle of the blade with a jigsaw.

The important thing to remember is to leave enough material along the outer edges for the next layers to adhere onto the finished piece. A ½" wide (10mm) border should be more than enough.

Now that the two blade halves are shaped and the excess weight has been cut out of the middle, it's time to put them together. For this step, they need to be placed on top of a couple of blocks that will keep them both flat and parallel (Figure I). Axe blades look funny if they're bent in the middle.

Now the cross pieces need to have holes cut into the middle in order for the handle to fit through. Then they can be slotted into the notches on the blades, as shown in Figure J.

In order to make sure that the parts all stay aligned during the gluing stage, now's a good time to take advantage of some clamps (Figure K).

These are bar clamps, just one of the countless varieties of clamps that you will need more of.

Applying glue to the seams

The pre-drilled hole will make it possible for the screw to effortlessly penetrate the MDF without splitting it apart.

Making a bigger hole for the screw head to hide in is called "countersinking."

Driving a screw

The bar clamps will hold the whole assembly together while the glue is applied (Figure L). Since MDF has a fairly porous surface, it can be held together with a cyanoacrylate adhesive such as Zap-a-Gap, Insta-Cure, or Super Glue. If those are too expensive, carpenter's wood glue will work just fine. It'll just take longer to cure and form a strong bond.

While the glue is probably going to be more than adequate to hold this whole thing together, it's always a good idea to be sure. In this case, it's a good idea to add a couple of screws to hold the bottom and top brackets onto the blade.

One of the biggest challenges when working with MDF is avoiding splitting the material when driving screws into it. Since it's basically just pressed wood garbage, it's really easy to wedge the bits of sawdust apart. This makes it a really good idea to pre-drill a hole everywhere a screw will need to be inserted. Start by drilling a small hole about the same size as the shaft of the screw (the skinny parts the threads stick out of). as you can see in Figure M.

Then, since nobody wants to see screw heads sticking out of the ends of the giant battle axe, a bigger bit is used to make the top of the hole a bit bigger in order for the screw head to sink into the MDF (Figure N).

Finally, drive a screw into that hole, secure in the knowledge that it won't do any more damage than absolutely necessary (Figure O).

Shenanigans. Note: No silly little dogs were harmed in the taking of this photo. In fact, the only way to entice this one to run away was to throw a ball (visible in her mouth) and chase her as she went after it. These are the things we do for comedy.

With the basic shape of the double-headed axe assembled, it's time to add a skin and make it pretty. Remove the handle and set it aside for now. Seriously. Resist the urge to do silly things with the as-yet-unfinished axe (Figure P).

Now it's time to cover the sides of the blade with a thin layer of sheet styrene. This can be purchased from plastic suppliers in various thicknesses. For smaller projects, you can use the plastic "for sale" signs available at your local hardware store. For even smaller projects, a variety of thicknesses of styrene sheet are available at your local hobby shop.

You're going to need a template and, in this case, a piece of butcher paper makes a good starting point. Simply hold it in place on top of the blade, and then use a crayon, pencil, or even a piece of chalk to do a rubbing. This means running the writing utensil back and forth across the piece. Everywhere there's a hard edge will become a darker impression on the surface, as shown in Figure Q.

Once the outline of the blade is clearly transferred to the paper, cut it out with a pair of scissors. This will give you the template you'll need for cutting the plastic.

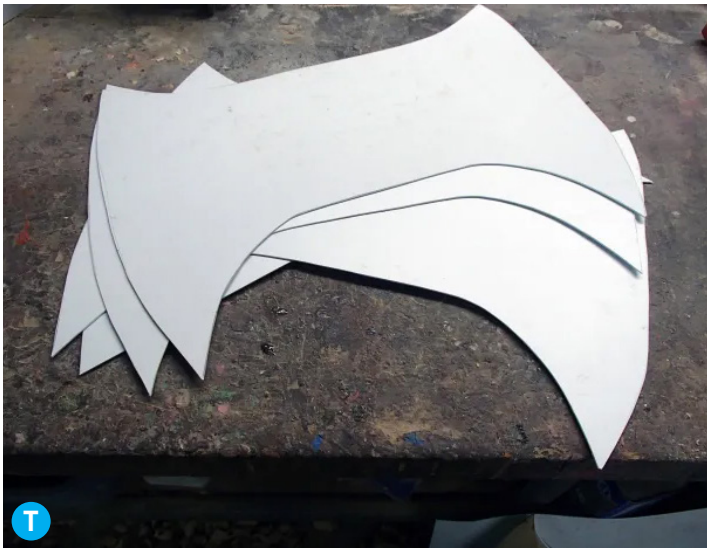
With the template cut out, trace it onto the sheet plastic, as shown in Figure R.

There are a few good ways to cut the shape out of the plastic sheet. The first option: use a saw such as a jigsaw, scroll saw, or band saw. If you don't have access to any of these, run the tip of a sharp knife along the traced lines to lightly score the surface of the plastic. Once the lines are scored, you can either repeat this step a few more times until the blade cuts all the way through the sheet, or you can go back over it one more time to cut just a bit deeper into the sheet and then bend it until it snaps along the scored line (Figure S). Just be careful because this method will create very sharp edges.

Rubbing with a pencil

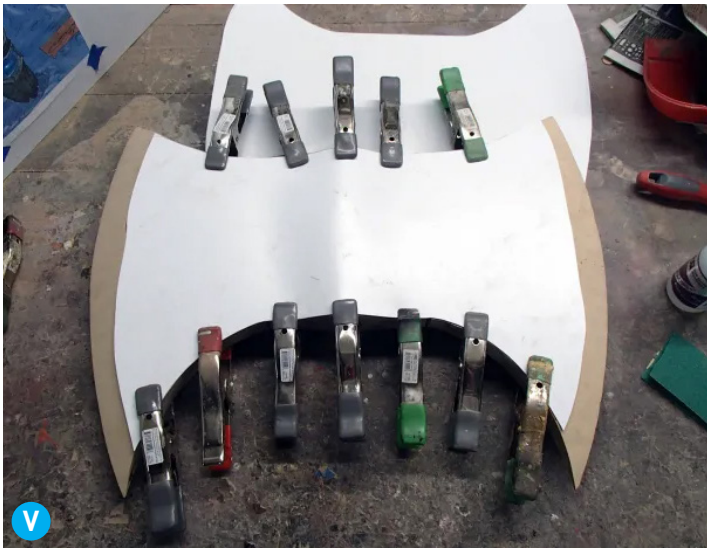
The shape traced onto the plastic sheet

Score and snap — the quick and easy way to get shapes out of styrene



Four shall be the number of the counting, and the number of the counting shall be four.

The world needs more spring clamps.



All of the available clamps. The more the better.

Mister Tongue Depressor (really just any small, flat piece of wood wrapped in sandpaper)

Repeat this step to cut out four copies of the styrene shape (Figure T).

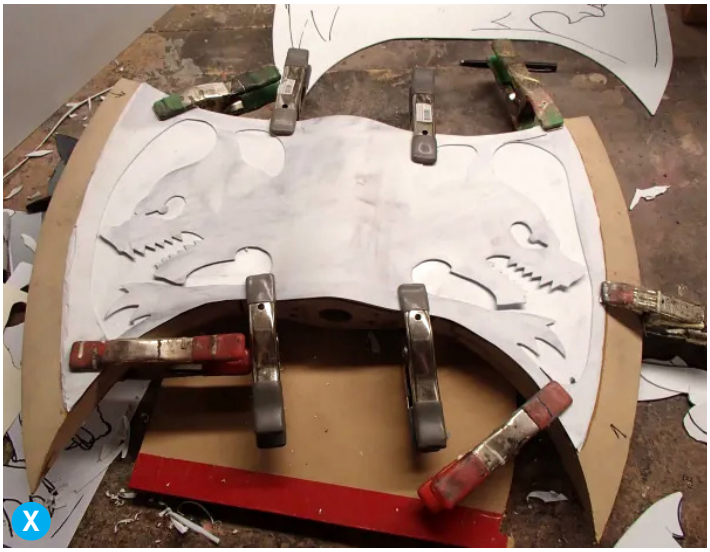
Pick any of these four pieces and fit it into place on the MDF blade without gluing it in place. Here's where a handful of spring clamps will come in handy (Figure U).

Dry-fitting the parts (assembling without glue) is a good idea. If it's not conforming to the curve where the handle will go through the blade, the sheet can be rolled by hand in order to pre-bend it so that it will lie in place better. Once the parts fit together neatly, you can apply glue to the MDF. The whole assembly can be clamped together securely while waiting for it to dry, as shown in Figure V.

Repeat the fitting, gluing, and clamping for the other side as well. Once the glue is dry, the head of the axe is nice and smooth on the outside. The edges of the plastic may need some trimming to sit flush with the edges of the MDF, but that's a quick job for a knife. Since this is going to be a much more elaborately decorated piece with designs etched into the surface, however, it's going to need at least one more layer.

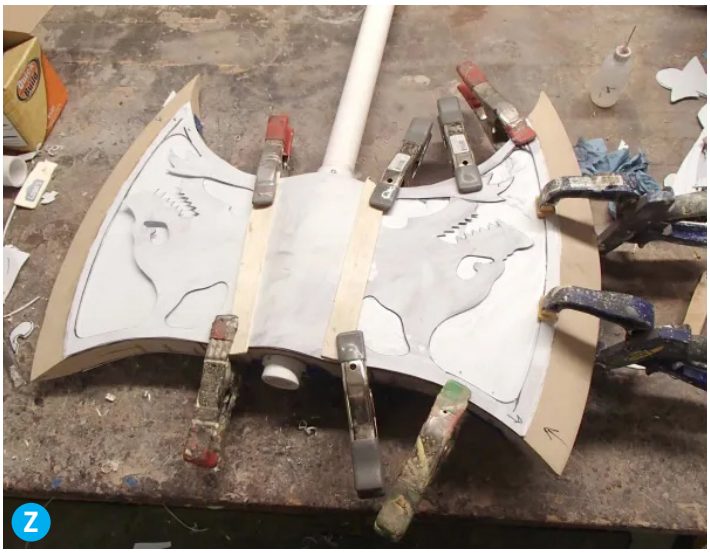
This last layer will end up making the higher areas bordering the etched recesses. This is a good time to cut out the recesses with a knife, or a jigsaw with a very fine blade.

When the pieces are cut, it's not uncommon for the edges to come out a bit rough. This can be readily solved with a piece of folded sand-paper. For the really tight corners, it's a good idea to get Mister Tongue Depressor involved (Figure W).

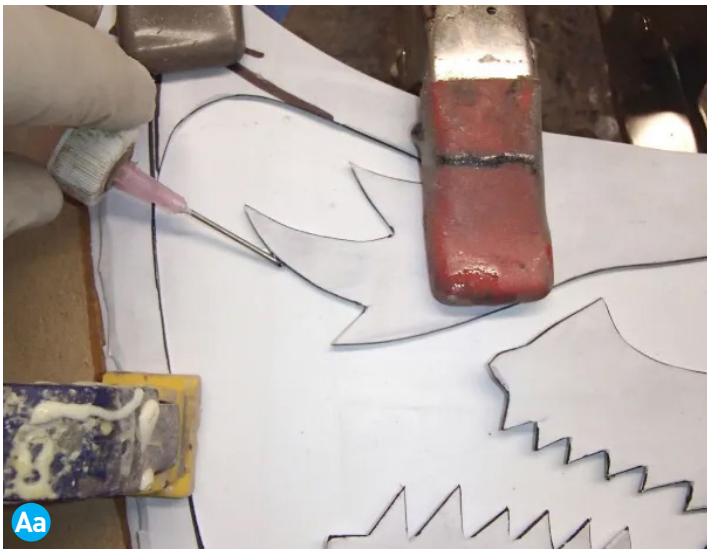


Looking good.

The handle installed with a set screw



Scrap strips of wood can be used to clamp the layers together without scratching up the surface.



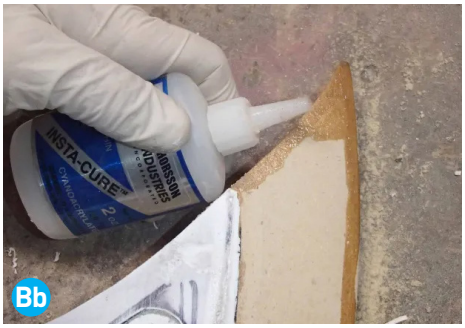
Using a syringe bottle to apply solvent cement to the seams

Once all of the edges are cut out, it's simply a matter of adhering this final layer to the layer below. Start by dry-fitting to make sure everything looks right (Figure X).

Before gluing on the final layer, now's a good time to attach the handle. This way it can be pinned in place with a screw. The screw hole will be covered up by the final layer of plastic sheet (Figure Y).

With the beginning of the handle glued in place, it's time to glue on the final layer of styrene. Since it may be a little tougher to get the parts to stick together, this is a good time to clamp thin strips of wood across the top of the parts to apply even pressure all the way across the work-in-progress, as shown in Figure Z.

NOTE: While the layers of styrene can be held together with the same cyanoacrylate-type adhesive that was used to get the styrene to stick to the MDF, a better option is a "solvent cement," which you can get at hobby stores or the same supplier that sells the sheet styrene. This type of glue will chemically dissolve a bit of the styrene on the surface. Once the solvent evaporates, all that's left behind is the solid styrene, effectively welding the two pieces together. Even better, this water-thin glue can be applied using a syringe bottle or special applicator after the parts are clamped together (Figure Aa). A drop applied at the edge will wick its way in between the parts by way of capillary action, meaning that the parts can be bonded after dry-fitting without disassembling them to add glue.



Soaking the edges of the blade with cyanoacrylate glue for strength

Smoothing the blade edge with a sanding block

The seams along the edge need to be hidden somehow.

Boring pipe fittings (left) stop being recognizable (right) with just a bit of love from a miter saw and a sanding block.

A groove carved into the handle to make it look less like pipe

The handle screwed in place

Now that the head of the axe is assembled, there's still a bit of filler and sanding work to do. Since MDF is basically just sawdust held together with really weak glue, it'll be easy to nick or scratch the surface of the blade's edge. These edges can be saturated with more cyanoacrylate glue to make them durable (Figure Bb).

As the glue soaks in and cures, the fuzzy sanded surface of the MDF will become rough and hard. Sand it smooth again with a sanding block (Figure Cc).

Finally, it's a good idea to use some spot putty or body filler to fill in the edges of the blade and smooth over the seams between the various layers of MDF and styrene (Figure Dd).

Now that the axe head is assembled and smoothed out, it's time to dress up the handle. This is a larger diameter piece of pipe with a PVC coupler glued to one end and a cap glued to the other end.

NOTE: Readily available PVC or ABS pipe fittings from the hardware store can be very helpful when building things that are cylindrical. The only problem is that a lot of these pieces will be easily recognized as pipe fittings. This can be solved by cutting them down in size, carving grooves into them, or grinding down the ends to make them less recognizable (Figure Ee).

In order to make the grip look less like an off-the-shelf piece of plastic pipe, carve a helical groove around it with a file and a sanding block (Figure Ff).

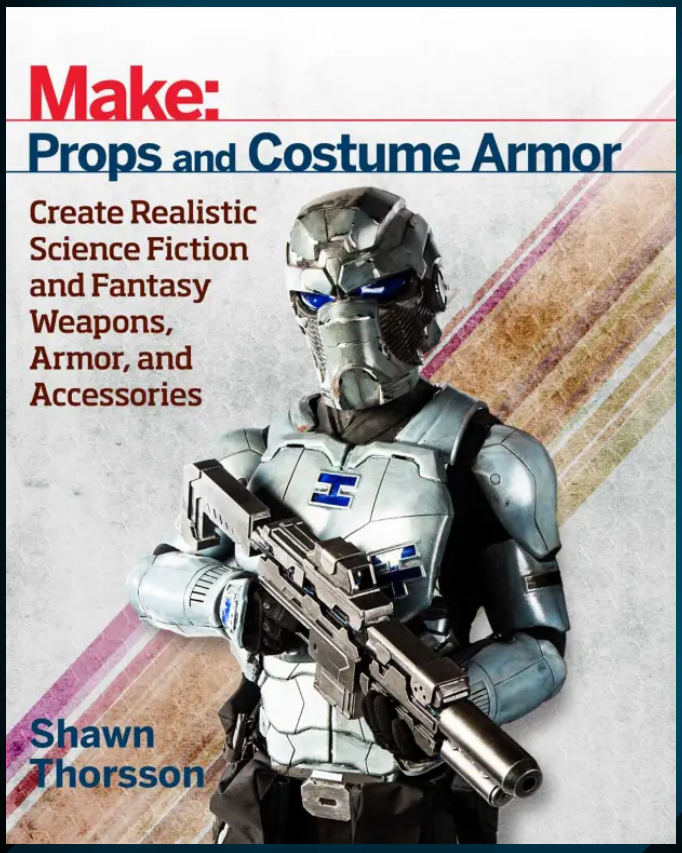
Slide the grip assembly over the smaller handle and screw it into place (Figure Gg).

NOTE: In order to keep everything from rattling around, the inner pipe can be shimmed in place by wrapping it with heavy paper or thin plastic scraps (called shims). Once the handle section is screwed in place, the gap between the inner pipe and the outer handle can be filled with a two-part epoxy putty available at most hardware stores. As an alternative, the gaps can be filled with auto body filler, casting resin, fiberglass resin, or a bunch of glue and sawdust. It's really just a question of getting the gaps filled with anything that will stay put once it cures.

Once the pieces are glued together, the whole thing needs a coat of primer and it's ready for paint (Figure Hh).

A bit of paint can do wonderful things.

The completely assembled battle axe in gray primer



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DIY Fume Hood

This build sucks — toxic fumes away from your workshop!

Written by Téa Forest

TÉA FOREST is a cosplay costume designer based in Toronto, Ontario. Her work blends traditional sewing techniques with digital fabrication tools.

One of the largest obstacles I faced when first starting to cosplay was what to do with all the toxic fumes created by a lot of products I needed to use, such as contact cement and spray paint. The easiest thing to do is work outside but that's not possible in all situations, especially during the winter.

This fume hood allows me to work year-round without the fear of breathing in toxic chemicals. It's a straightforward build that anyone can do, and with a few adaptations it can also be used for laser cutting fumes, 3D printing fumes, and other noxious or obnoxious emissions.

1. ASSEMBLE THE BOX

You can cut the plywood sheets yourself, or get them cut (when you're buying them) by most hardware stores for a small fee. Show them the cut diagram (Figure A) and they should be able to cut it for you. They'll probably tell you they can't be that precise but that's okay for our needs. Since the fan will be pulling air into the box, having some small gaps in places is OK since all leaks will be inward, not out into the room. (You may notice that my box has the bottom sticking out a little bit, because I didn't account for the thickness of the plywood — but that's fixed in the final measurements.)

Start by attaching one of the side pieces to the back panel. Using the #8×1½" screws, screw through the side, into the edge of the back panel. Putting the bottom into place can help you line everything up (Figure B on the following page). Some tape or a helping hand might be necessary to hold things together while you get started. We did 5 screws per side.

TIME REQUIRED:
A Weekend

DIFFICULTY: Easy

COST: $500–$700

MATERIALS

- **Furnace filters, 16×20×1 (2)** from any hardware store
- **Carbon filter, 8"** We ordered an 8", 720 CFM air filtration kit from Vivosun (vivosun.com) that includes the carbon filter, inline fan, dryer vent hose, and 2 duct clamps.
- **Inline fan, 8"**
- **Dryer vent hose, 8"**
- **Duct clamp, 8"**
- **Roll of aluminum foil tape**
- **Duct reducer, 8" to 6"**
- **Straight duct boot, 6"**
- **Plywood sheets, ½" thick: 4'×8' (1) and 2'×4' (1)**
- **Quarter-round moldings, 5/8", 8' long (4)**
- **Wood screws: #8×1½" and #5×1"**
- **Felt furniture pad strips (2–3 packs)**
- **Acrylic sheet, 30"×32"**
- **Painter's tape** to hold things in place while you screw
- **A window that can open**
- **Straps** to secure the filter to the top of the box. Our kit came with 2 straps but you could also use some metal strapping with ½" screws.

TOOLS

- **Compact hacksaw**
- **Jigsaw (optional)**
- **Drill/driver with bits** including a ½" drill bit
- **Screwdriver**
- **Pencil** for marking
- **Measuring tape**
- **Plastic cutting tool (optional)** if acrylic sheet is too wide

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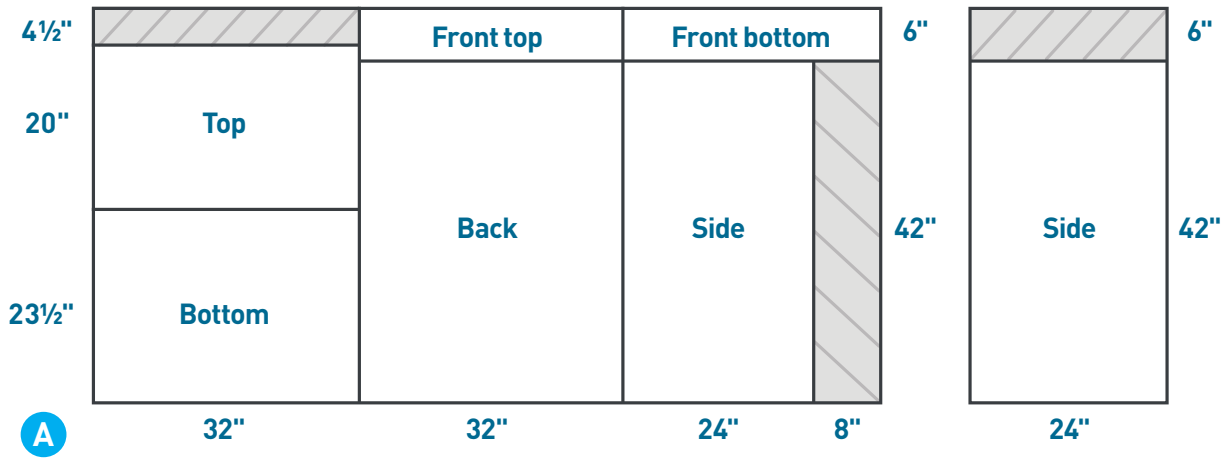

TIP: For every screw in this build, remember to drill a pilot hole first to prevent splitting the wood.

Next, attach the bottom by driving screws through the side you just screwed on and through the back piece, into the edges of the bottom piece. You can prop the whole thing up on some extra pieces of wood or anything else you have lying around to be able to get a good angle on it (Figure C). Now that there's a good solid corner it is much easier to attach the other side to the back and bottom.

The last part to attach for now is the top. Lay the whole thing on its back and wedge the top piece between the 2 sides, pushed flush against the back piece (Figure D). You might have to loosen the screws on either of the side pieces first, if it was cut a little big. Screw into place.

2. SECURE THE FAN AND FILTER

With the box still lying on its back, test-fit the fan. It should be up at the top of the box with the fan on whichever side you want the air duct to exit (Figure E). Mark where to make a hole on the side using a pencil.

To get started cutting this big circle, first drill some holes using the ½" drill bit. If you're using a jigsaw, 4 holes around the perimeter of the circle should be fine. If you're using the hacksaw you'll have to make the holes much closer together since the hacksaw can't cut curves (Figure F). Cut out the circle by connecting the holes.

Using the ½" drill bit again, drill one more hole close to the big circle you just cut out, to feed the fan's power cord out of. Saw a gap between the two holes large enough to fit the cord through (Figure G).

Put the fan and filter into place, making sure the arrows on the fan are pointing the airflow outside of the box. In order to get the filter in straight, you may need to start the fan and filter on an angle (Figure H) and turn it into place. You could also loosen or remove one of the sides if you're still having difficulty.

Now it's time to mount the filter to the roof of the box. The air filtration kit we bought came with a couple straps, so all that was needed was to drill a couple holes in the roof of the box using a ½" drill bit and I was able to loop the straps

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F


G


H


I


J


K

through (Figure I). The filter is not very heavy so this is enough to keep it up. If yours didn't come with straps, you can use some metal strapping with ½" screws to secure it to the roof.

Once you're sure everything is working you can use some of the aluminum tape to make the connection between the fan and filter more secure, but it's OK to leave it for now.

3. ATTACH THE FRONT

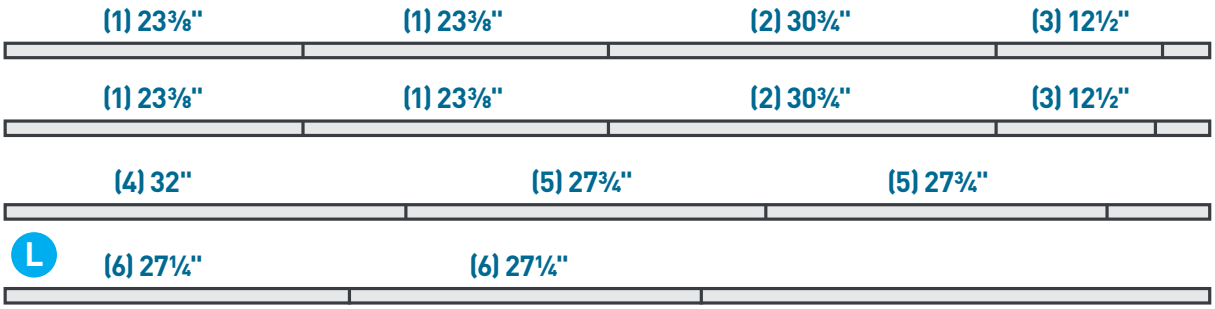
The front is made up of two pieces, so that this project be can be cut from as little plywood as possible. We'll start by attaching the top front and then move to the bottom front. For this step you'll either need someone to come hold things while you screw, or you'll need a lot of tape to hold things in place.

Position the top front piece under the edge of the top piece and screw down into it through the top, using more of the 1½" screws (Figure J). Then, making sure you won't hit the screws coming down from the top, screw into it through the sides too. To make sure you'll hit it, first measure and mark where to drill.

The bottom front piece is secured the same way through the sides (Figure K).

4. MAKE THE SLOT FOR FURNACE FILTERS

There are 13 pieces we need to cut from the quarter round molding. Here's a diagram with the approximate lengths but I'd recommend measuring the space where you need to put them on your own fume hood to get more accurate

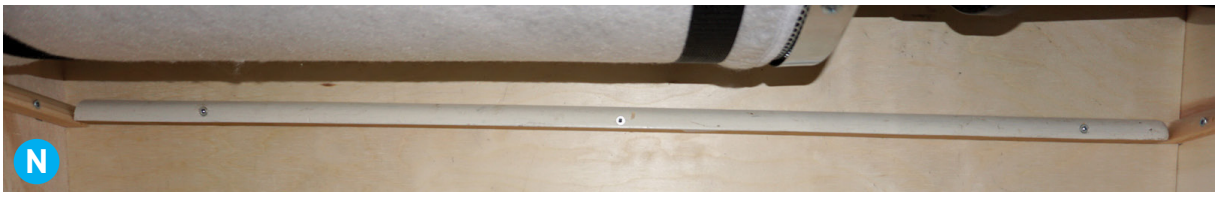


measurements (Figure L). Cut them using the compact hacksaw.

The easiest place to start is to line up a piece (1) just inside the bottom edge of the box front, with its other end pressed against the back panel (Figure M). This molding has two flat faces; you'll want one against the side and the other facing toward the bottom of the box. Screw it on, using the 1" screws. I found it was easiest to first drill a hole then use a screwdriver to manually screw the quarter round into place. Do it again on the other side. Then take a piece (2) and line it up on the back between the two pieces (1) you just attached, and screw it on (Figure N).

Repeat with the other pieces (1) and (2) to create a 1" gap below the box front (big enough for your furnace filter to slot into), except this time one of the flat faces on the moldings should point up instead of down (Figure O).

There's one more piece needed to complete the filter slot and that's the piece that goes across to hold up the front of the filters, piece (4). Position this piece in line with the other 3 you just attached, 1" below the box front. Screw in, starting from the outside of the side panel, the same way you attached the front pieces (Figure P).



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Two furnace filters will slot into this space, side by side, so they're easy to change out whenever required.

5. MAKE A CHANNEL FOR THE ACRYLIC PANEL

The rest of the quarter round pieces are used to guide the acrylic front window or *sash*, as it slides up and down. Apply the felt furniture pad strips along one face of each quarter round, and along the side edges of the box front. These will prevent the acrylic sheet from scraping when it's moved up and down. Put any extra strips along the bottom edge of the box front to help with scraping there as well.

Line up piece (6) with the front face of the fume hood, with its felt facing outward and one end resting on the box bottom, and screw it into place (Figure Q). Find something that is about the same thickness as your acrylic sheet to use as a spacer. I used a couple paint stirring sticks. Sandwich them between the already attached piece (6) and piece (5). With the spacer between them, screw piece (5) into place with its felt facing inward (Figure R).

Repeat a similar process on the top with piece

(3), using the spacers again but this time lining the end up with the box top.

Do it all again on the other side.

The acrylic sheet should now be able to slot into the channel between the quarter round guides, and slide up and down with ease (Figure S). If it doesn't fit, now is the time to trim it down using the plastic cutting tool.

6. VENT IT OUTSIDE

Even though the air is being filtered it still must be vented outdoors to be totally safe (Figure T). Using a duct clamp, secure the 8" dryer vent hose to the part of the fan sticking out the side. I found using metal tape alone wasn't strong enough to hold it in place. Use the duct clamp, then you can tape around it for extra security.

Cut the vent hose so it's long enough to reach your window with a little extra wiggle room. Tape the 8"-to-6" reducer to the 6" duct boot using more aluminum tape. The rectangular shape of the boot makes it easier to vent out a window. Once attached, put the reducer on the end of the vent hose, securing it with tape once again.

All that's left to do is open a window and stick the duct boot in it. Fill any extra space with a piece of wood or cardboard. Depending on the weather where you live, you might want to take it out whenever it's not in use to close the window.

FUMES-B-GONE!

Turn the fan on and you're ready to go! Using one of the wood off-cuts, you can prop up the acrylic sash to make room for your hands to fit inside while you're painting or spraying. If your fan is quite powerful you may need to raise the sash a bit further to let in enough air.

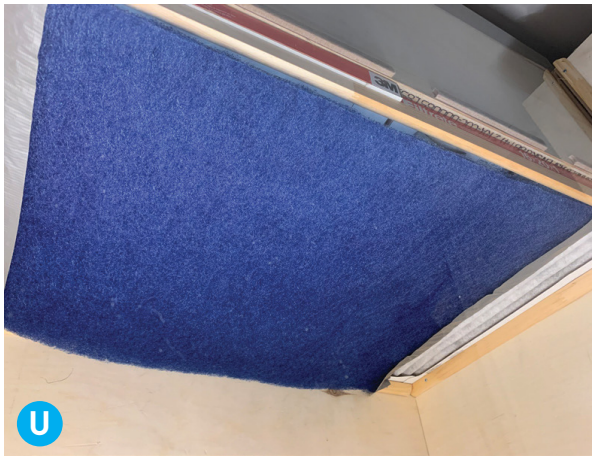
When spray painting, I tape a washable fiberglass furnace filter to the bottom of the other filters to catch the larger particles (Figure U).

Remember to leave the fan on while anything is drying inside as well, since it could still be giving off fumes.

EASY UPGRADES

Now that all the basics are done you can upgrade your fume hood by mounting a light inside or adding a power strip somewhere handy.

A fancy paint job would look nice, or even just



Téa and Andy Forest

V

some stickers. For mine I opted to laser-cut some foam to make it look like Kirby was sucking all the air up (Figure V).

Lining the bottom of the box with kraft paper can be a big help with cleaning as well.

LASER CUTTER FUME EXTRACTOR

This build can be easily upgraded to serve as a fume extraction and filtration system for laser cutting. The key is to add more particle filtration for cutting wood, more carbon filtration for cutting acrylic, and potassium permanganate pellets to filter formaldehyde like in MDF and other engineered-wood products.

This fume hood box design is perfect for adding more filters at the top; just stack up what you need! Go for 4"-thick, pleated filters with a coarse filter first, on the bottom, and then a finer filter on top. You can add more carbon filters at the top if you make ductwork to connect them together.

At the Steamlabs makerspace in downtown Toronto, we made a system to filter the exhaust from our 120W laser cutter (Figure W). The filter box has coarse Camfil 30/30 D9 25×20×4 filters first, then fine Camfil Opti-Pac OPMV14 24×20×4 filters next. For filtering acrylic, MDF,

W

and other fumes, the system next goes through two pollution control barrels in parallel. These are from General Carbon and each is filled with 86 lbs of silicate compound impregnated with potassium permanganate (GC HS600) and 108 lbs of granular activated carbon (GC 4x8S).

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