SWOOP
CHAIR

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ARTSTUDI 254
Spring 2013

So you’re gonna make a chair?

Start somewhere!

Don’t be afraid to pick something early, and focus on that from week 1. There’s not enough time in the quarter to explore everything, so start narrowing your focus around your favorite types of chairs and materials you’d like to use.

For me with the Swoop Chair, the starting points were the ergonomic experience I wanted to create (semi-lounge) and the material I wanted to use (bent plywood). I think I had pretty much picked even by week 2, but I still felt torn. Commit early!

And you have some ideas...

Design and learn manufacturing in parallel.

There's a lot of pressure to nail down a final design ASAP, but if you can hone in on a manufacturing technique and a material, you can practice while you keep your design open. Definitely have an idea of what you want to do, but iterate on the design as you learn from the material.

In making Swoop, I thought I had a design pinned down, only to learn more advanced techniques that blew my design wide open again. The final design was only realized once I had finished all my prototyping and practice.

One last tip!

Making a chair is art and engineering.

Don't overlook the engineering required to make your chair solid. Consider whether you'll be happy if your final chair is gorgeous but wobbly. It's really hard to pull off a wild design in 10 weeks, so be prepared to compromise on either the sturdiness of the final chair or on the crazy concept in your design.

Be ambitious, but also realize that there won't be time to prototype every aspect (structural and aesthetic) of your chair. Prioritize what you need to for your own sense of success, and do your best to compromise as little as possible on everything else.

I never got to prototype with full plywood thickness and full scale, so even though I'm really happy with the final result, it was a bit more flexible than I wanted, and so I feel like Swoop is just a great prototype. Takeaway? Prototype, over-engineer, and simplify.

Materials

I chose to use bent plywood, which meant I needed a lot of super-thin veneers and epoxy to laminate them together. If you're thinking of plywood, keep reading. If not, you might start skimming since its about to get pretty specific.

Our class found awesome veneers from Macbeath Hardwoods called "All-wood" veneers. Unlike standard paper-backed veneers, allwood have two structural layers on each veneer. The main wood (cherry, in my case) is mated orthoganally to a cheap luan. This means you can bend very tight radii without snapping the main wood along the grain, and that every shape you cut is already paired against an orthogonal grain, which is good for design purposes.

I chose cherry for its big grains and rich color, but the grain pattern repeats more than on some other woods, which makes me wish I had chosen something else. Ask them to take out your top two or three contenders to see them up close!

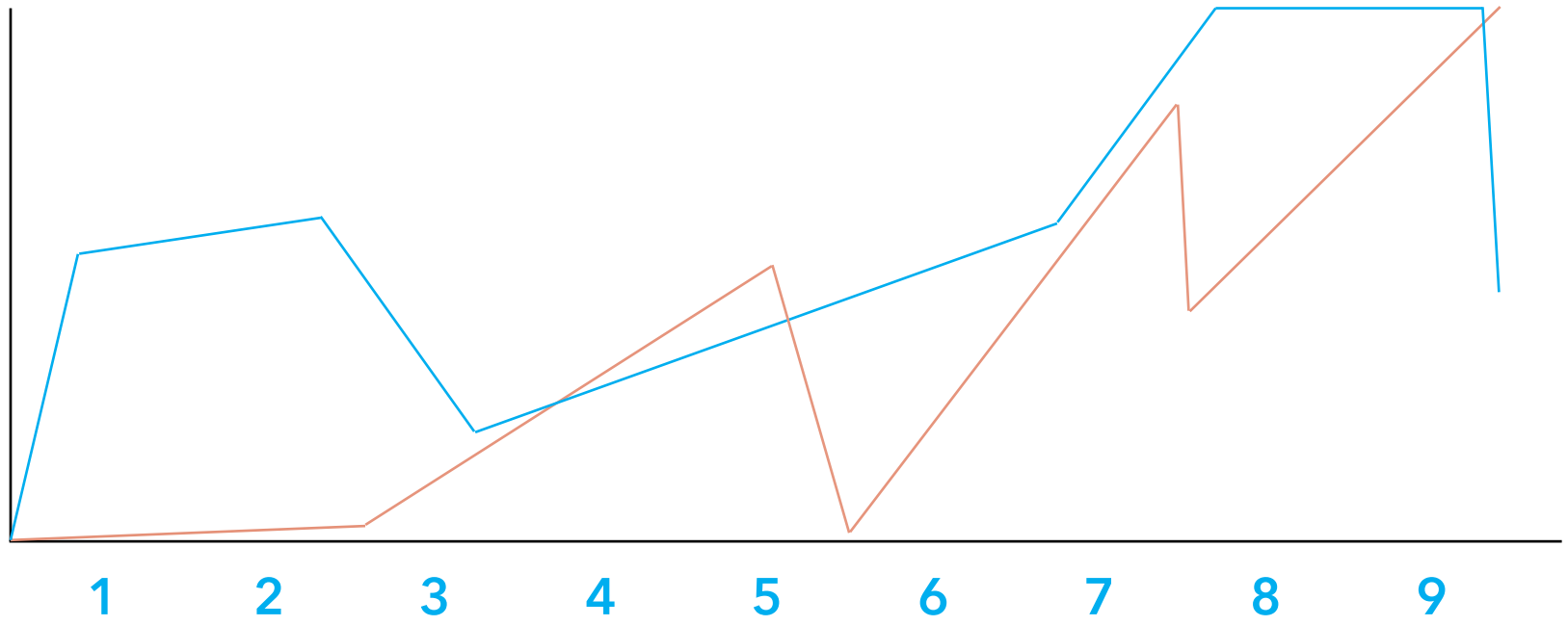
Costs

Description	Details	QTY	Each	Total
Oak veneers for practice	8'x4'	3	$70	$210
Cherry veneers for final	8'x4'	8	$90	$720
West Systems epoxy (105/207)	Gallon	1	$200	$200
West Systems pump dispenser	all sizes	1	$10	$10
RTV silicone	4oz	2	$7.50	$15
		GRAND TOTAL		$1155

There wasn't a whole lot to a chair using exclusively plywood. Except for really expensive veneers! I strongly suggest using cheaper veneers for the internal layers (e.g. oak), since you can barely tell what kind is in the middle because they all have luan on the back. Choose the outer layers carefully. If you're not getting the same kind all the way through, hand-pick the veneers. If you get all the same veneer, you'll be able to find at least two decent cuts that are free of knots or marks. I used West Systems 105 epoxy and opted for the 207 (extra clear hardener, medium cure time) for the laminations., The RTV silicone is a great, pliant adhesive for joining separate pieces, because the epoxy doesn't give at all and can tear the individual veneers apart.

Process overview

Here's a map of my process... Tracking progress and intensity.

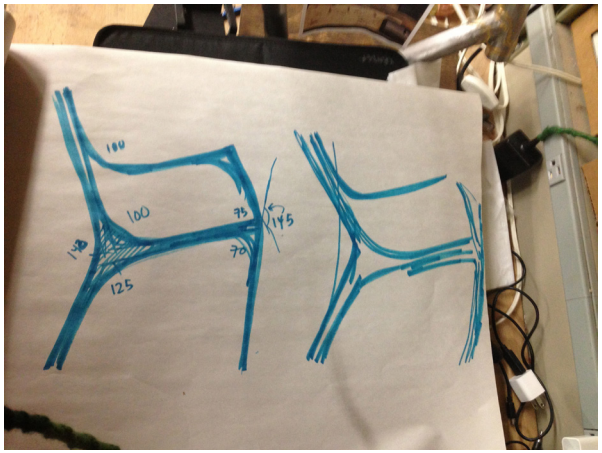


The cardboard chair made for a quick start to the quarter. It actually ended up helping my design, both for a type of chair and a sits-like prototype. Then it was into design, sketching and doing quick manufacturing prototypes to test layups patterns and making small shapes. Then I did full scale prototyping, before going back to the drawing board in one last flurry of design before starting the real thing.

Early designs and cardboard chair

My design started with the cardboard chair assignment. Looking back, I can see that I easily chose my focus on a one-week project, but agonized over the 10 week version. In the end they were quite similar!

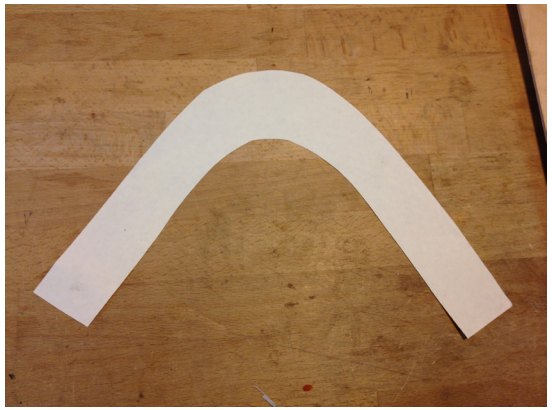
Swoop started with a simple sitting geometry that I preferred. I used this on my cardboard chair, as well as in all my sketches and in a sits-like prototype. These early sketches were exciting for me on paper, but failed to live up to my expectations when modelled in 3D. I was trying to design for standard buck-bent plywood, which can only bend in one dimension at a time.

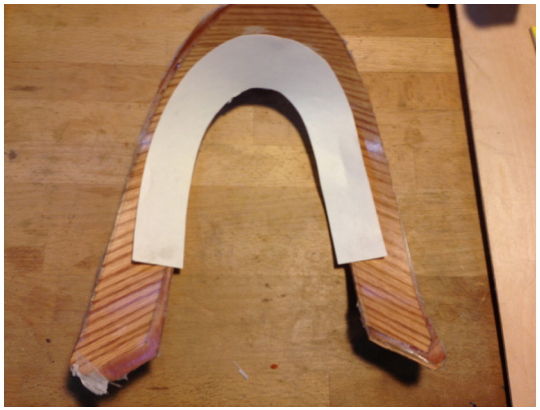


Manufacturing prototypes

John and I worked a lot on developing the outside vacuum bagging technique, where only the veneers and epoxy are in the vacuum. When bending plywood, you need to apply pressure to compact the veneers together while the epoxy dries, but also hold the veneers in the shape you'd like them to finally hold. Traditional bucks attempt to apply even pressure all across the desired shape - both at once.

Using outside vacuum bagging, we separated the shape from the pressure. This meant anything that could be made in bent card stock (not folded!) could be made in wood. All you need to do is prototype the key points of clamping. We also tested ply layering.

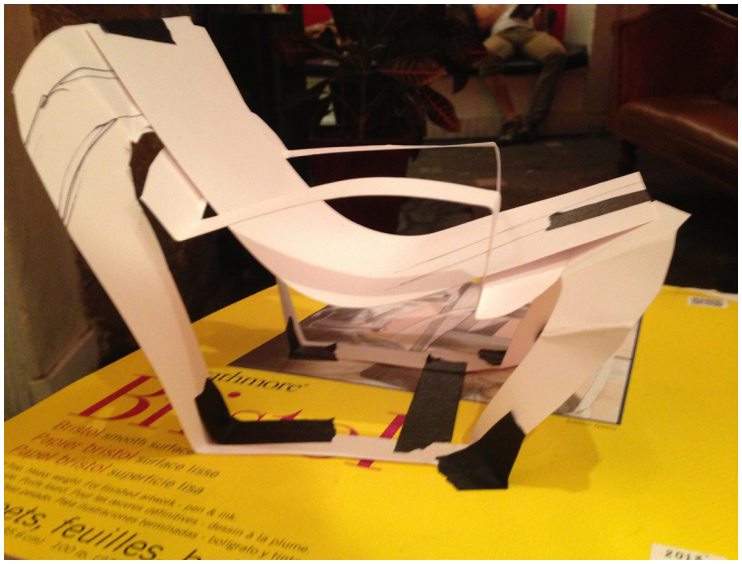


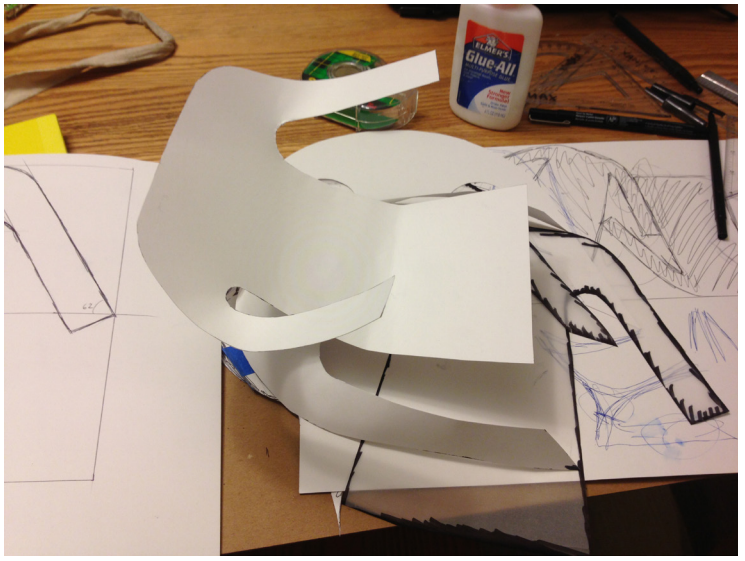


Later designs

After working a lot on the vacuum technique, I felt a lot more free in my designs, having separated the need to apply even pressure and shape to the veneers with a buck. More complex shapes were now possible (exciting), but it was getting pretty late in the quarter!

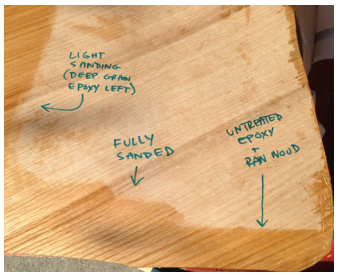
I sketched more but relied heavily on cardstock bending to prototype my final shapes. It was much easier to visualize forms in 3D than in a sketch.





Manufacturing practice and scale prototypes

With some better ideas of how to employ the outside vacuum technique, I went back to prototyping to practice the actual forms I hoped to make, first in small scale (around 1:3), then at full scale using my sits-like prototype as a jig.



These tests gave me many important insights in technique, design, and finishing. I saw how the bag acted around the arms of the chair, the challenges of bending points and the weight of the clamps at full scale, and had new ideas for my design.

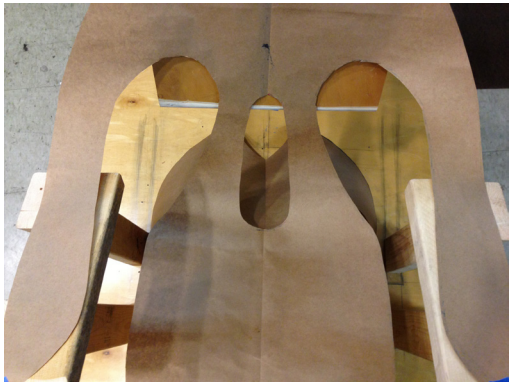
Bending and prototyping jig

After doing scale manufacturing prototypes, I had knew ideas and needed a quick way to visualize them. I also knew that I'd need a more flexible and minimal jig for manufacturing the critical contact points but without getting in the way of free-flowing bends.

I made a new jig, and started using it to prototype my latest designs. Using butcher paper and masking tape, I was able to quickly iterate on my ideas and trace out changes very easily.

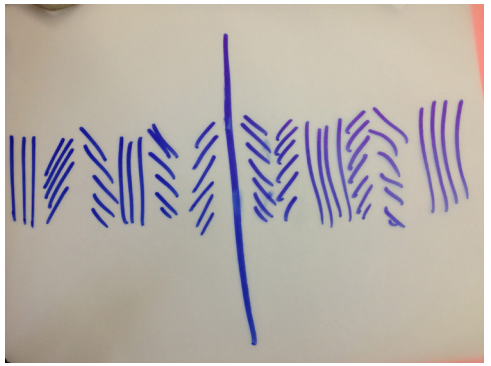
Final design

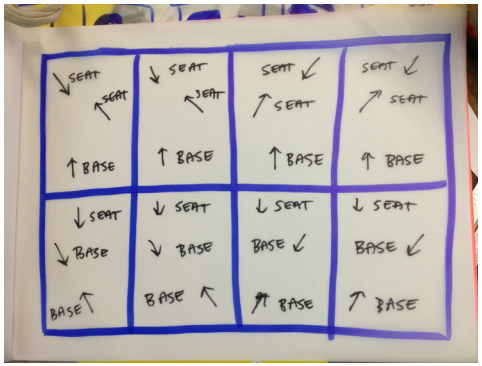
The new jig allowed me to converge quickly (with just 10 days to go!) on a final design that had a much stronger visual appeal than earlier prototypes, and let me cut in confidence. I carefully folded over the paper to mirror it to perfect symmetry, and then added 1/2" on all sides to account for shifting and material loss. Then I started cutting veneers.



Layup preparation

I mapped the full thickness of my chair based on an alternating pattern of veneer grains, and carefully planned where each piece of that layup would come from on the veneer. I had to nest shapes, and mix base and seat pieces to get the right orientation for each piece. The good news, was scissors was all I needed! The edges need post-treatment anyways, so careful but rough cuts are OK.





Final layup of base

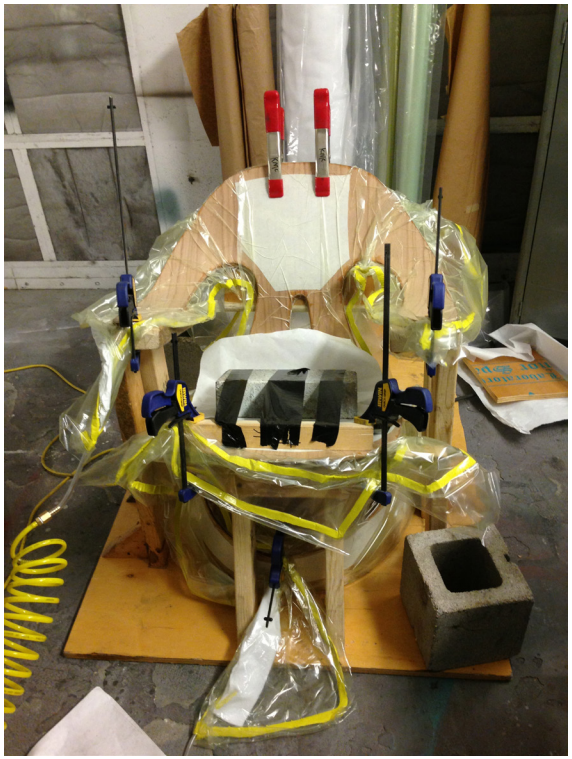
The layout of the base was a bit tricky, because we needed to create a full 3D shape from a flat layout and vacuum bag, and constrain in with a clamp at a critical point. We did a dry run just to make sure everything fit properly before using epoxy. Then we made a vacuum bag, including separate sections for the pieces that folded around the jig, so the bag didn't pull the part around. Then we added epoxy, increased vacuum, and clamped!

The lessons learned from previous errors made this layup quite successful. The separate vacuum bag sections were cut to allow free movement after the bag was fully sealed, and this allowed for a nice, even curve. Word to the wise: be careful with clamps, they'll may make a small dent wherever you put them unless you add a pad.

Final layup of seat

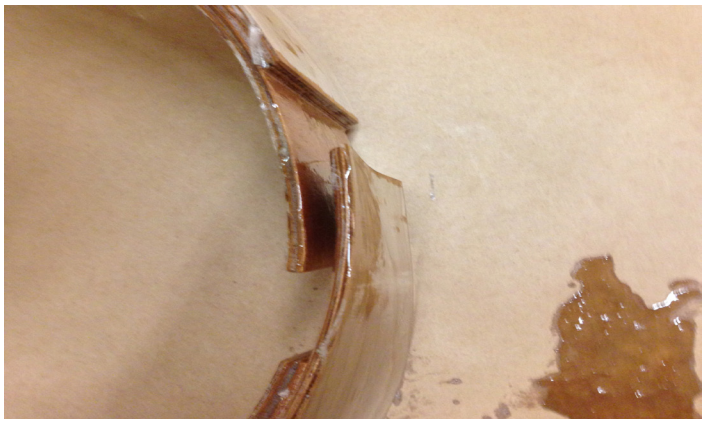
The final layup for the quarter needed three people, and four didn't hurt! We did a dry test, made a bag, did the wet layup, then cut slots into the final bag to allow for free movement of the arms. Then it was all about creating symmetry on the base and ensuring that the neces-sary points were clamped.

I could have made the jig a little more constrained to eliminate guess work on the fly, but our eyes are pretty good measures. Just some-thing to keep in mind. And plan your clamps carefully ahead of time!



Creating the lap joint in the base

During the dry layup, I trimmed the appropriate ends of the base to pre-form the lap joint.



I clamped the pieces together during curing, so I had to carefully spread them apart to clean up the joint with a sharp chisel. I did this before any finishing of the edges of the base. Once they fit together well, I joined them with epoxy and clamps.

Finishing

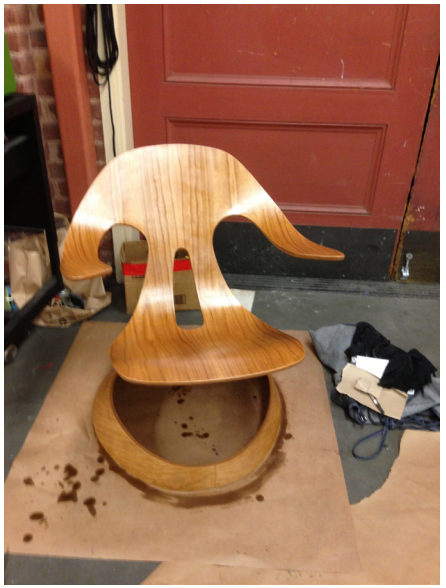
Finishing was a daunting task because of the mulpti-ple bends in my piece. I started by using the big tools in the woodshop, but quickly found that I was able to work far more efficiently using hand tools.

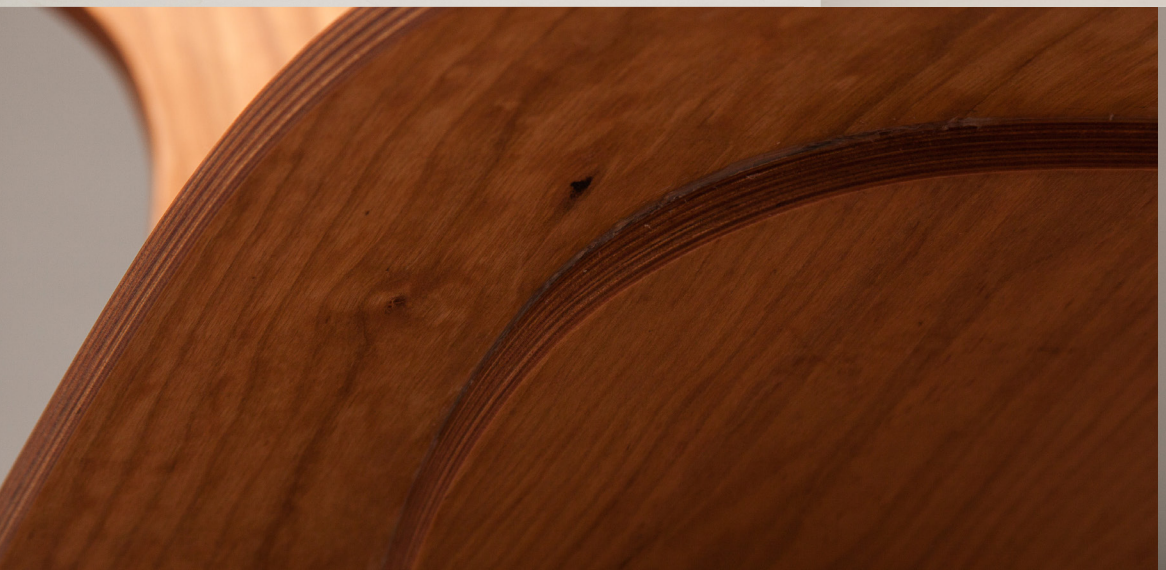
I used an angle grinder to quickly create the desired curve along the edges and eat away the excess epoxy sticking to the side. Then I followed up with a multi-tool with 60 grit sandpaper to start shaping smooth curves. I gradually worked up to 220 grit over the whole chair, smoothing edges, removing scrapes, and taking down epoxy that penetrated my masking of the surfaces.

Joining the pieces and applying linseed oil

At this point there was only one challenge remaining, to join the pieces evenly and strongly. I used 100% RTV silicone (for marine applications) to join the two pieces of my chair, and chose Jorgenson's clamps for their deep throat to maximize the clamped surface area.

After the silicone dried, I was able to test the chair by sitting on the joined pieces. Low and behold it worked! All that was left was to apply linseed oil, which Craig Milroy recommends and filled me in on the details. Basically, heat it up to warm, wipe it on, then wait 15 minutes, and wipe off excess. Then wait 24 hours, clean with a soft Brillo pad, and repeat. I got three coats on before the show.





SWOOP
CHAIR

Laminated cherry plywood
30”x30”x24”

The Swoop Chair brings modern vacuum technology to the plywood lamination technique pioneered by Charles and Ray Eames in the 1940’s. Swoop re-imagines the Eames’ lounge chair for the 21st century.

Final tips for plywood bending

In no particular order...

GENERAL
- prototype curves, clamping, layering, thickness, and vacuum bagging.
- complex bends can create unexpected inflection points around surfaces you want to become flat after a bend.
- screw CAD, use cardstock!
- practice until its easy, and buy enough material to practice.
- make a really good for your bending to prototype shapes and refine your design.
- pre-plan where each piece will come from your sheets of veneer.
- mark each side of each layer of veneer to show which sides mate to each other.
- mark even the inner layers of the veneer as little and as lightly as possible.
- mask the outer-facing sides with waxed/plastic coated paper from the laser cutter
- duct tape can be an awesome clamp

LAYUPS
- when making a vacuum bag, fold the vacuum sheet in half and then run the tape over one side at a time, closing the remaining three edges. Press the tape to the bag with a smooth, firm touch.
- cut the bag around parts that need to bend far distances.
- scoot the bag up around areas that will need more slack to prevent pulling from a tight bag before applying vacuum
- apply about 7-10psi vacuum and then roughly shape your part before applying full vacuum, then clamp after full vacuum is achievied.
- use pieces of plywood to disperse clamping pressure.
- don't trust that anything will be perfectly flat or straight or a certain radius unless you constrain it to be so (using a male and female buck, for example).
- spread epoxy on the top of your part - minus the outer layer - then work all the way to the bottom, and go back and add the outer top layer last.
-wear clothes that you're OK sending to be trashed when you're done

Tools and materials

PRL T&M

- vacuum pump
- vacuum accessories
- vacuum bagging
- vacuum tape
- sanders
- rubber gloves
- linseed oil
- clamps
- butcher paper
- wax paper

Personal T&M

- veneers
- epoxy
- dispensers
- mixing cups
- stir sticks
- angle grinder
- multi-tool
- sand paper
- files
- RTV silicone
- clamps
- duct tape
- scissors
- apron/spare clothes

Inspirations

Thanks

First off, I have to thank John Edmark for his tireless efforts to make sure that everyone had a successful final product. He was amazing in thinking through every detail of the project and helping us stay on track.

Thanks also to Anja Ulfeldt - our awesome TA - who handled everything for us, had lots of great design insights, and took awesome glamour shots of our hard work.

Thanks also to the entire group of 2013 chair designers. It was a really awesome experience with all of you, learning with all of you, helping and being helped by all of you.

And special thanks to Katie Zhou, Lea Eton, Kevin McElroy for their help in my layups. Also to the PD Loft for awesome feedback, and Emily Fraser for her invaluable input.

And to you, for reading!