ME263: THE CHAIR

DAYDREAMER

ELEGANT AND FUNCTIONAL

THE DAYDREAMER ALLOWS ITS OCCUPANT TO RECLINE IN SUPREME RELAXATION

CONSTRUCTED OUT OF TWO 4X8 PLYS

THE DAYDREAMER CAN BE CNC CUT AND
ASSEMBLED IN LESS THAN 2 DAYS TIME

INSPIRATION


SCHIZZO


TOMMY MAC STEAM BENT


GRAVITY BALANS CHAIR BY PETER OPSVIK


THE LAYER CHAIR BY NICK GRAHAM


THE GRASSHOPPER CHAIR


JOE MANUS ROCKER


SCATE CHAIR

DESIGN MANIFESTO

ORGANIC - THE DESIGN WILL BE NATURAL AND EVOKE FEELINGS ASSOCIATED WITH LIVING THINGS.

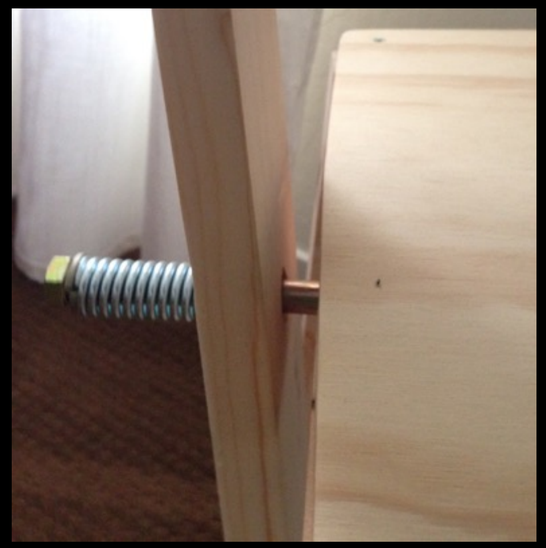
SERENDIPITOUS - I LIVE BY A CONSTELLATION OF VITAL PHENOMENA. THIS CHAIR WILL BE THE END RESULT OF MANY SUCH EVENTS.

THOUGHT-PROVOKING - I WANT MY DESIGN TO KEEP ITS USER GUESSING— HOW WAS IT MADE? WHY DOES IT LOOK THE WAY IT DOES?

JUXTAPOSITION - BLEND MATERIAL AND CONTEXT NOT ORDINARILY FOUND TOGETHER.

FLOW - ELICIT MOVEMENT, SMOOTH LINES. A CLEAR BEGINNING AND END.

CHAIR IN A WEEK



CONSTRAINED TO USING A HALF SHEET OF PLYWOOD AND TWO 2X4S

My chair in a week introduced me to the nuance of chair design. From finding an appropriate floor-to-seat height, the correct angle for back support, and ideal seat width, length, and slope, I had to consider factors beyond mere aesthetics.

I hoped that with its rounded corners and organic shapes, my chair would elicit something playful but stable. With its curved spine, it resembles a stingray.

To add to its playful nature was the incorporation of a spring to the rear of the chair. Leaning back, the splat of the chair flexes to better support your preferred angle of recline.

OBJECTIVES

Originally I wanted to use my Computer Science background to parametrically design my chair and then 3D print it.

Unfortunately I soon discovered that this was economically infeasible.

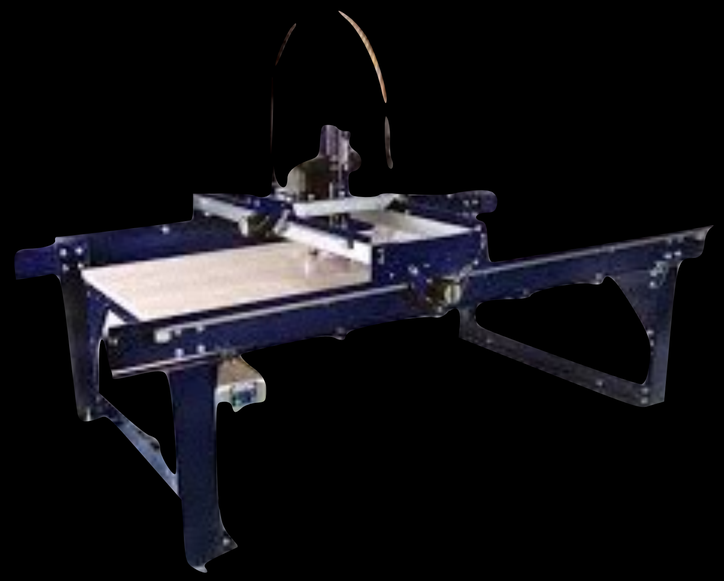
The cheaper methods of 3d printing produce material that is prone to shearing and structurally unsound.

Instead I decided to design my chair in CAD and then use a wood CNC router to cut pieces (layers) that I could then assemble into my final model. This had the benefit of making a chair that used very little material and would be quick and easy to manufacture.

For CAD I opted to use Rhino.

I HAD NEVER USED RHINO OR A CNC BEFORE, SO THIS WOULD BE QUITE THE CHALLENGE.

Rhinoceros®



CONSTRAINTS

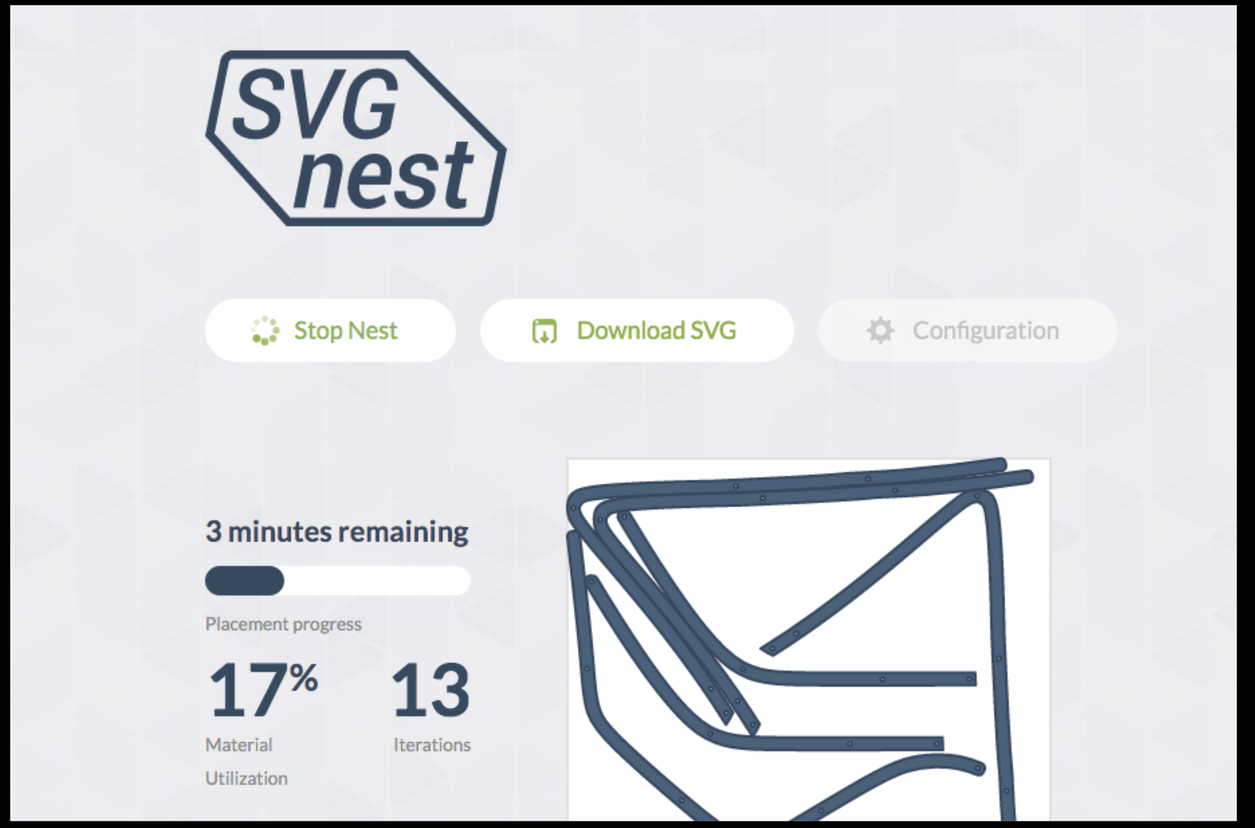
I DECIDED TO RESTRICT MYSELF TO USING A MAXIMUM OF TWO SHEETS OF 4X8 PLYWOOD

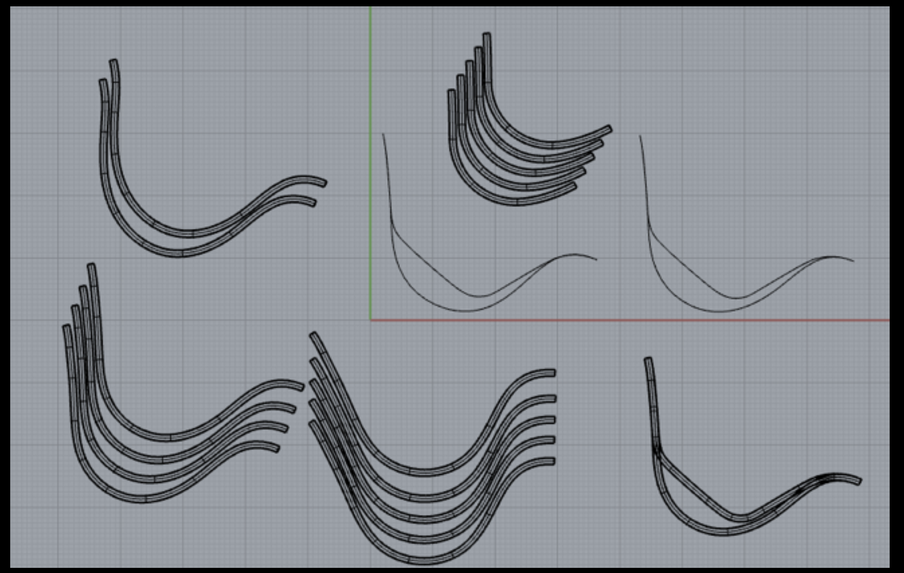
This had more of an influence over my final design than I expected.

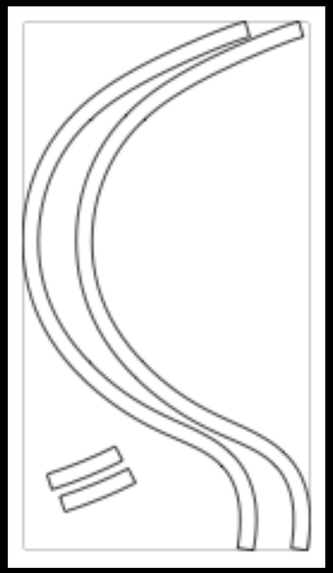
It turns out that some shapes are much better at being nested than others.

I used a website called SVGNEST.COM, which offers a free online service for vector nesting, intended for use on CNC machines as well as laser and plasma cutters.

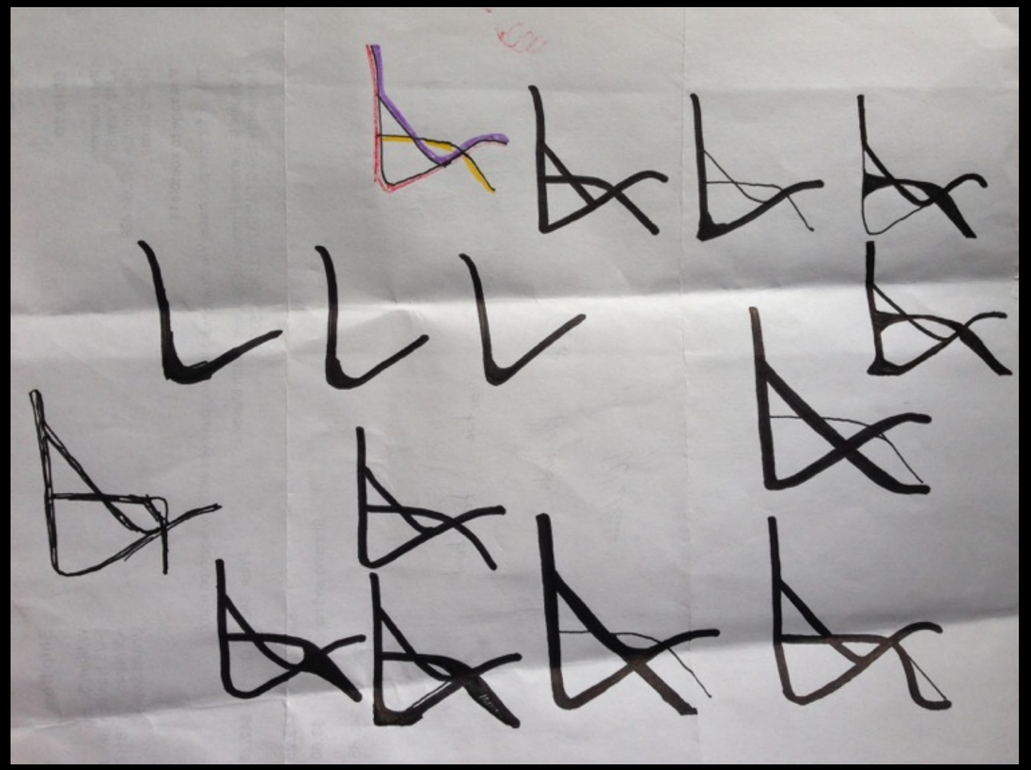
SVGNEST is open source and utilizes a genetic algorithm for trying many different placement variants and optimizing material utilization.

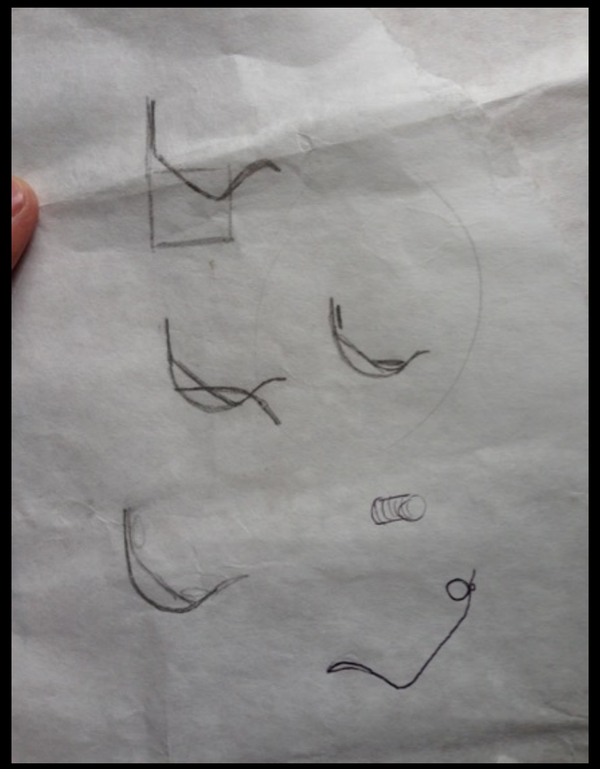


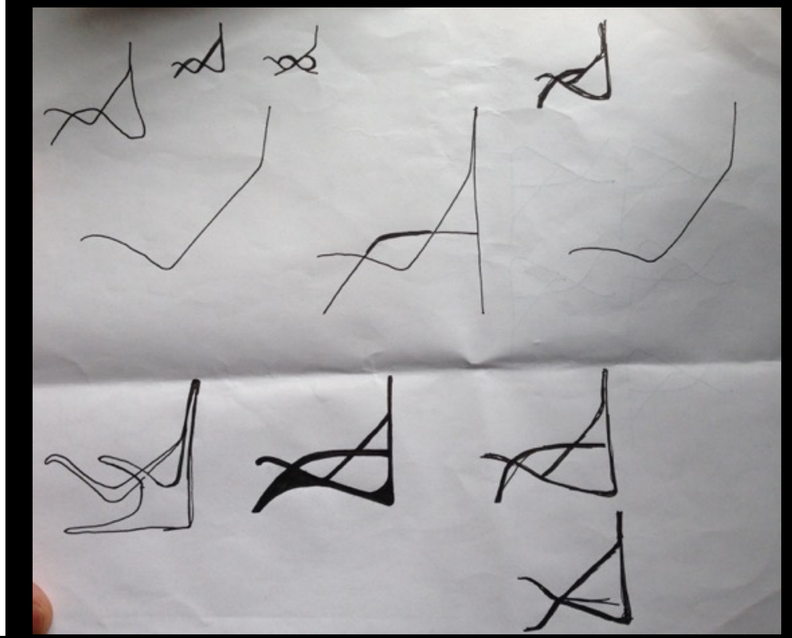


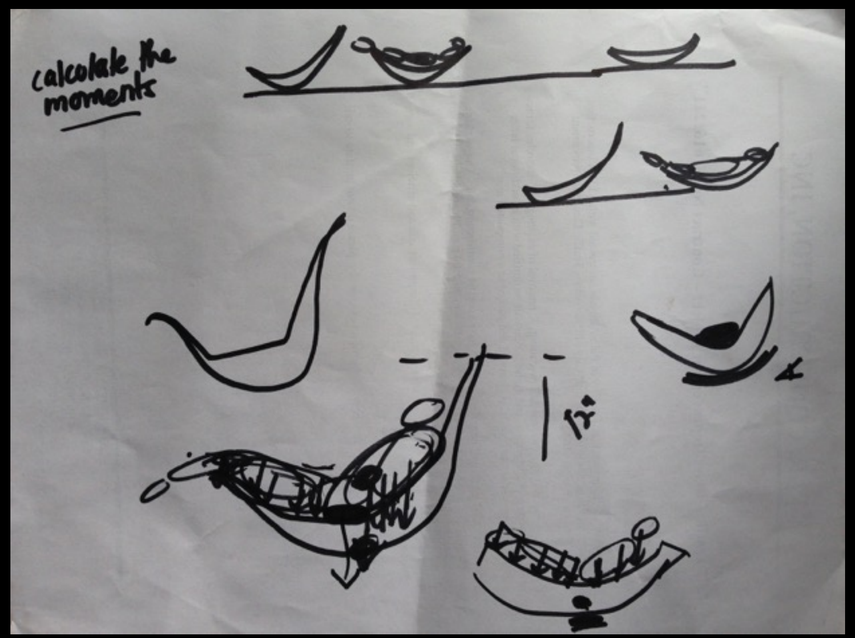


DESIGN EXPLORATION (PAPER)







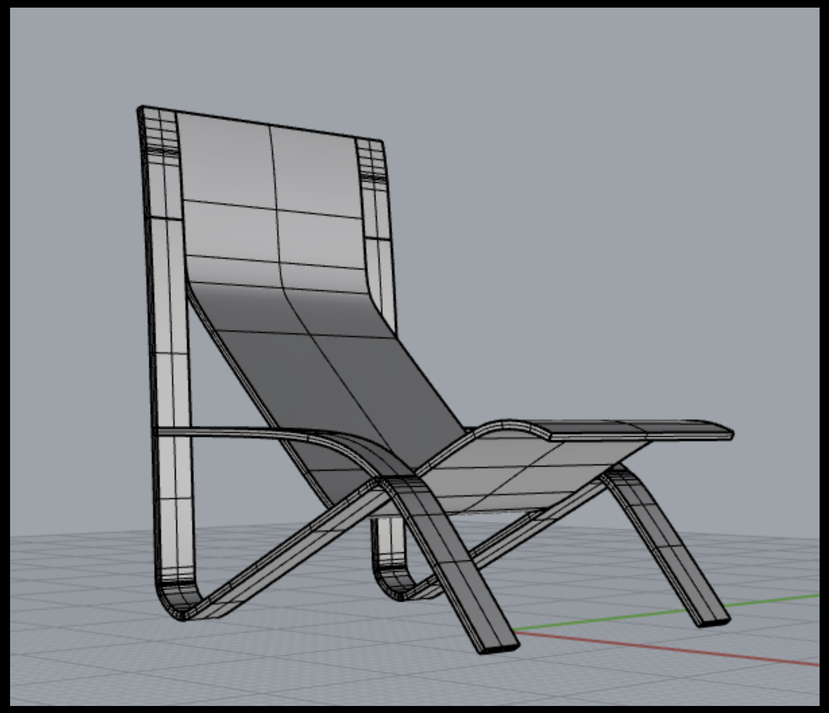


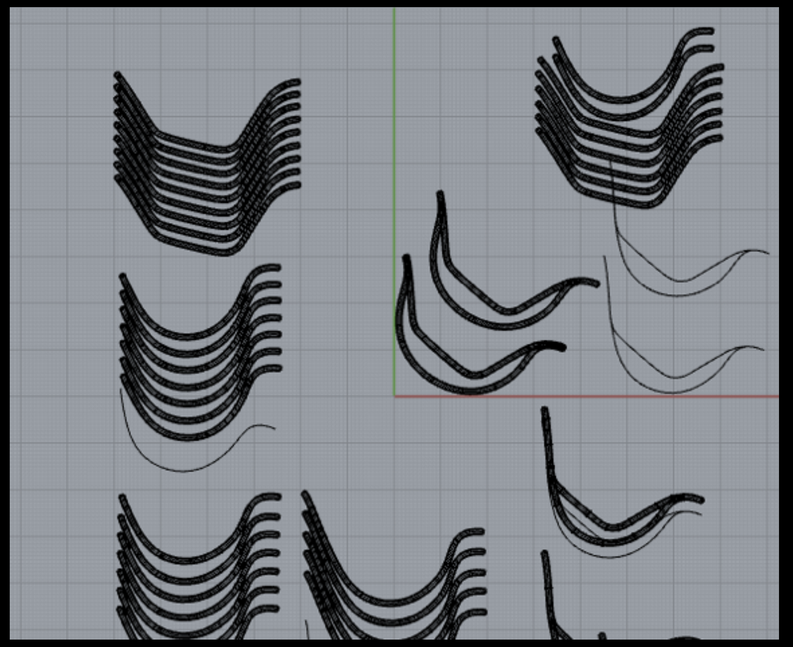
Originally I designed my chair to be stationary, built of 3 pieces: one for the seat, one for the back leg and one combined for the front leg and arm rest.

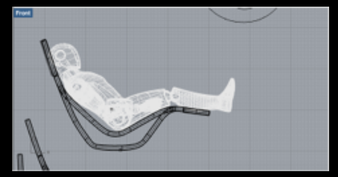
As my exploration progressed, I realized that 3 pieces would require too much material.

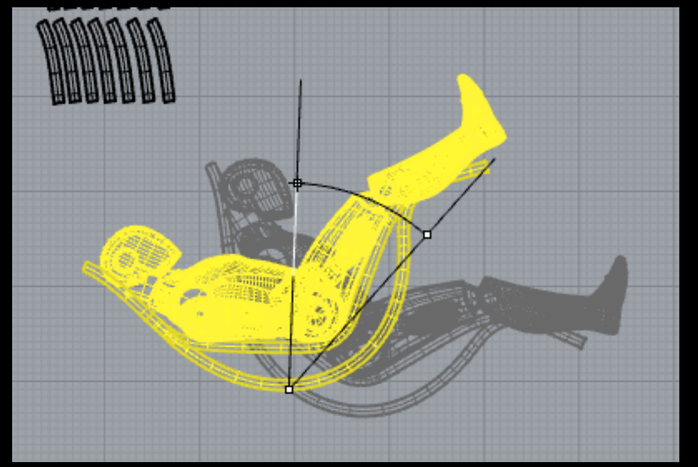
Instead I opted to design a rocker with 2 pieces: one for the seat and the other for the rocker.

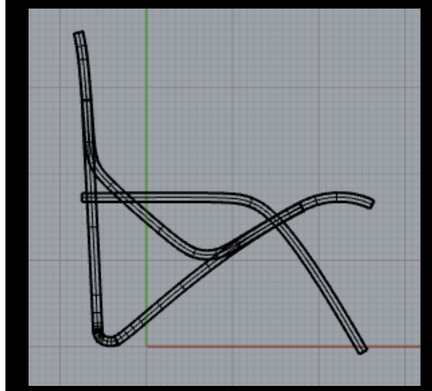
DESIGN EXPLORATION (CAD)

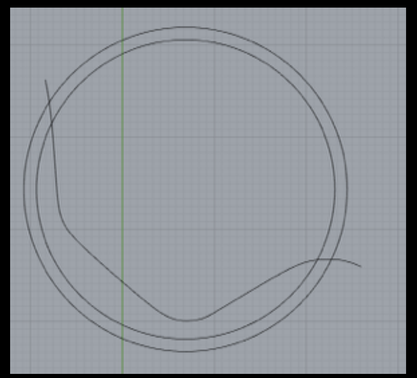


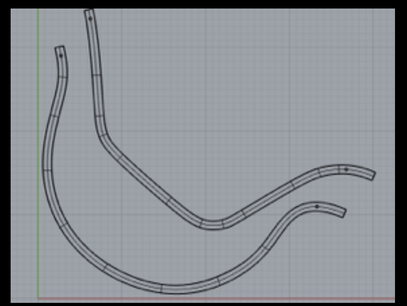


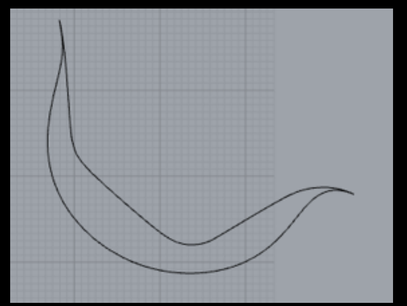


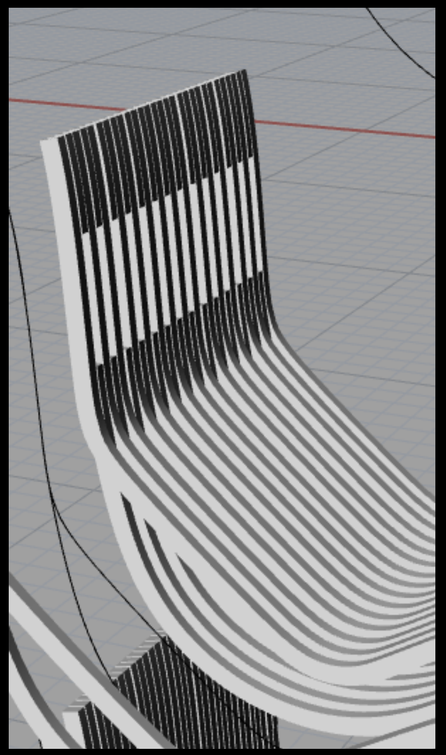


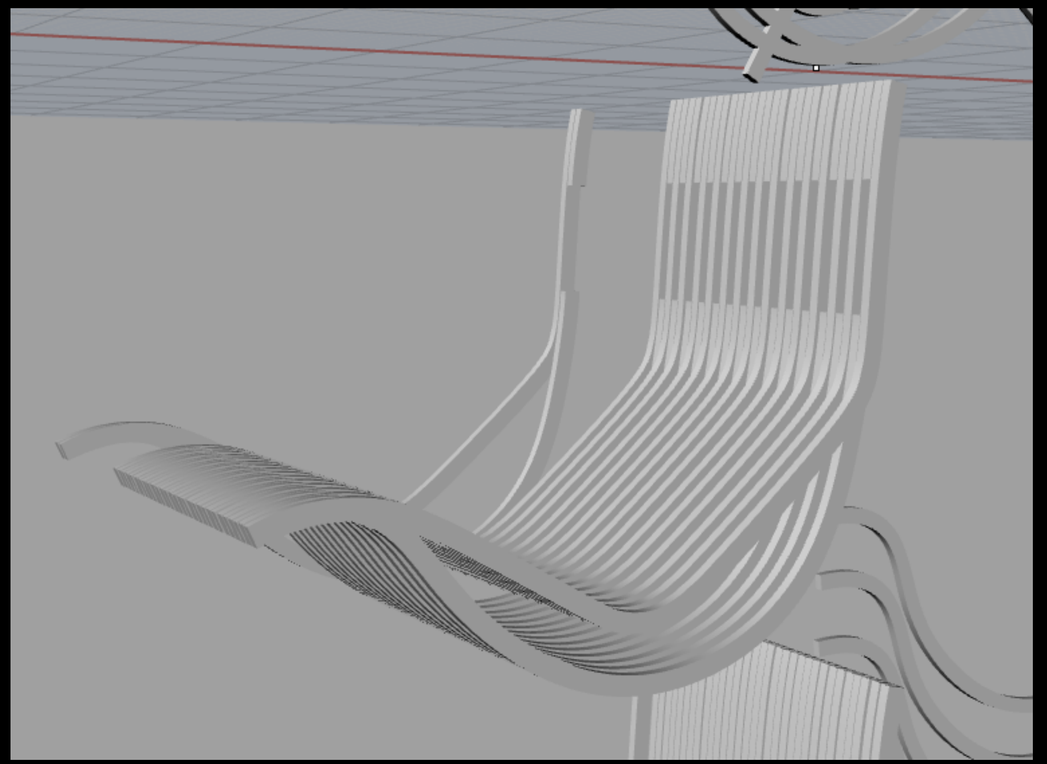




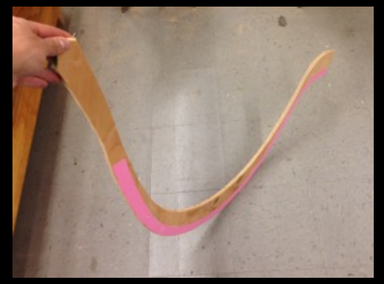


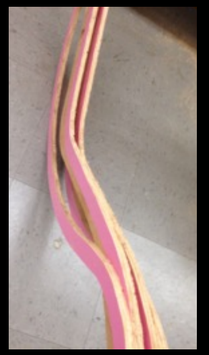






PROTOTYPE ONE





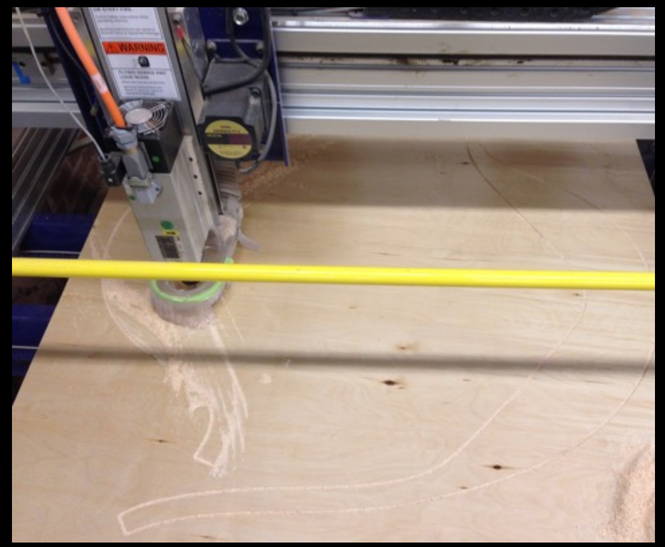
To prototype the rocking mechanism, I vinyl cut a sticker to apply to a 1/2” plywood sheet that guided my cut with a jig saw and a band saw. I then used self-drilling drywall screws to fix additional strips of plywood as a seat.

PROTOTYPE ONE LEARNINGS

While structurally sound and capable of rocking, P1 revealed a number of problems I'd have to address for my final design. In its neutral state P1 was well balanced. However with the addition of an individual's body weight, the chair leaned forwards heavily. To achieve the reclining position with one's feet off the ground I desired, P1 needed a heavy brick balanced above its occupant's head. Obviously this was not ideal.

Alternatively, to keep one's feet grounded, the seat length would need to be chopped off towards the end. Additionally the head rest was positioned too far forwards to be comfortable.

PROTOTYPE TWO



P2 WAS ALSO ASSEMBLED WITH SELF-DRILLING DRYWALL SCREWS.

The tool I chose to use was a 1/4” downcut bit. This tool left a clean edge on the top half of the plywood, but the bottom edge was jagged and required sanding.

For P2 I decided to get down and dirty with the shopbot wood CNC.

I cut the side profile of the chair, adjusted with the seat’s center of gravity shifted backwards, the foot rest lobbed off and the headrest sent slightly backwards.

To create the tool paths, I exported my Rhino model into an Adobe Illustrator (.ai) file, which I then cleaned up and imported into VCARVE.

PROTOTYPE TWO LEARNINGS

Unlike P1, P2 did not balance well. Without an occupant, its weight was shifted to the rear. This I remedied by building a foot rest attachment to lengthen the existing one. Despite the foot rest weighing so little, its position so far out from the chair's center of gravity helped to adjust P2 to a more normal default position. P2 had a smooth recline—one felt supported even when leaning all the way back. P2 evoked a feeling of weightlessness since its occupants could recline in any position simply by subtly shifting their center of gravity. However, P2 immediately sent its shorter occupants backwards on their first sit—most found this fun, but uncomfortable.

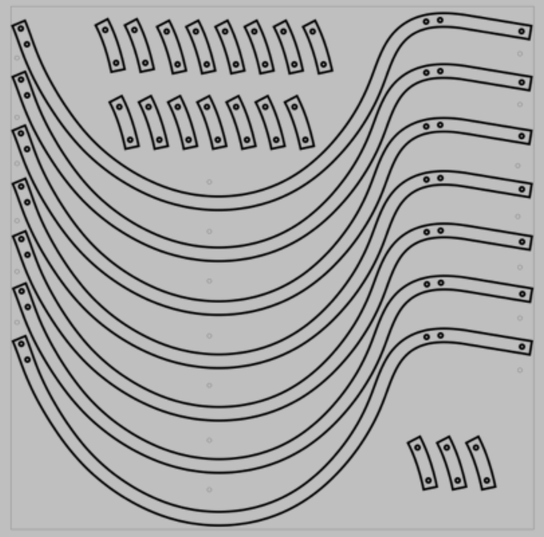
PROTOTYPE THREE

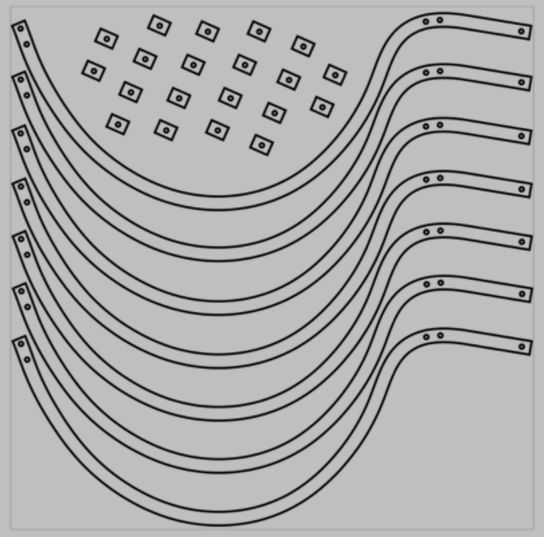
P2's chief complaint was the subtlety at which the seat would move based on small variations in one's center of gravity. P3 was an attempt to limit that subtlety by creating a neutral rest point or line segment along the arc of the curve at which the chair would lie when stationary.

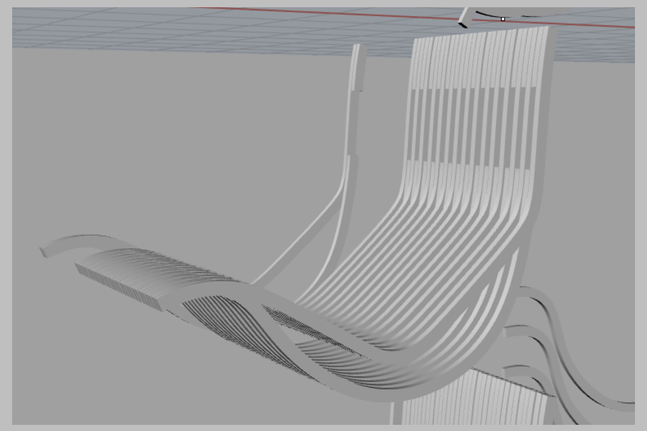
However, I discovered after fabrication that this design lost the "fun" factor of P1 and P2 because by "locking" its occupant into place rather than allowing them free reign of their recline, it simply wasn't as comfortable to sit in. P3 was missing the magic floating feeling that P2 so evoked.

I DECIDED TO ABANDON THIS IDEA.

FINAL DESIGN



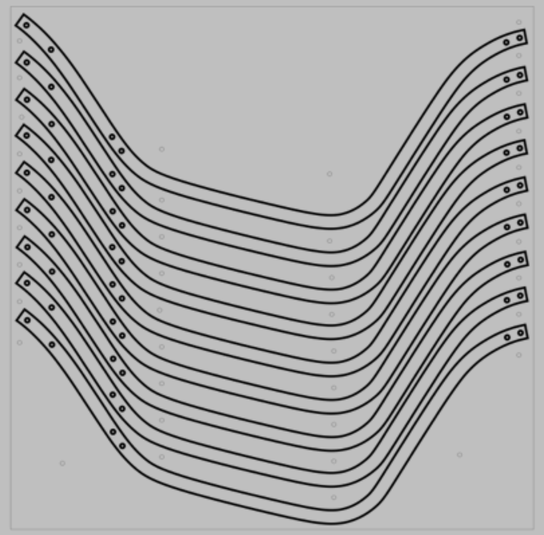


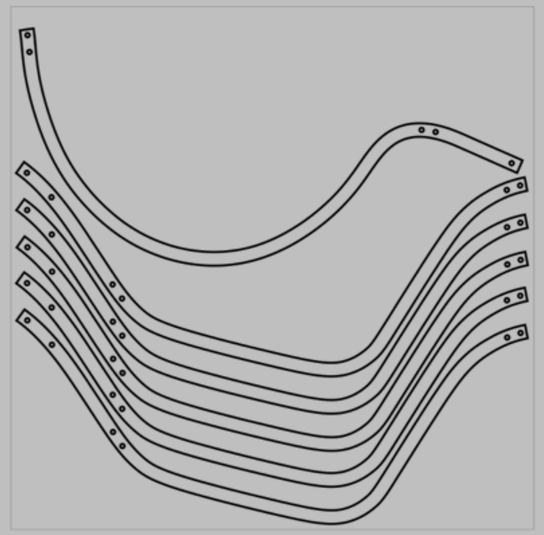


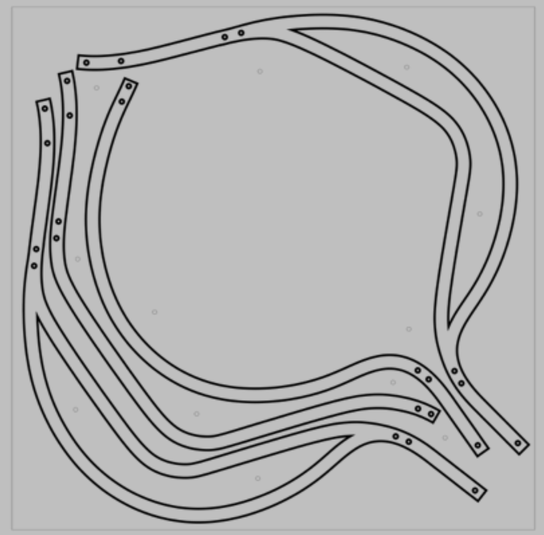
This design combined successful elements from the three previous prototypes.

Since the bed of the shopbot at the PRL is 4ft x 4ft, I needed to fit all of my pieces into separate 4x4 panels.

Unfortunately this meant that I would have to introduce short end pieces that would extend the longer pieces beyond the available cutting area. While adding new pieces would make the assembly more difficult, it would also allow me to create aesthetically pleasing segments of empty, negative space along the outline of the chair.



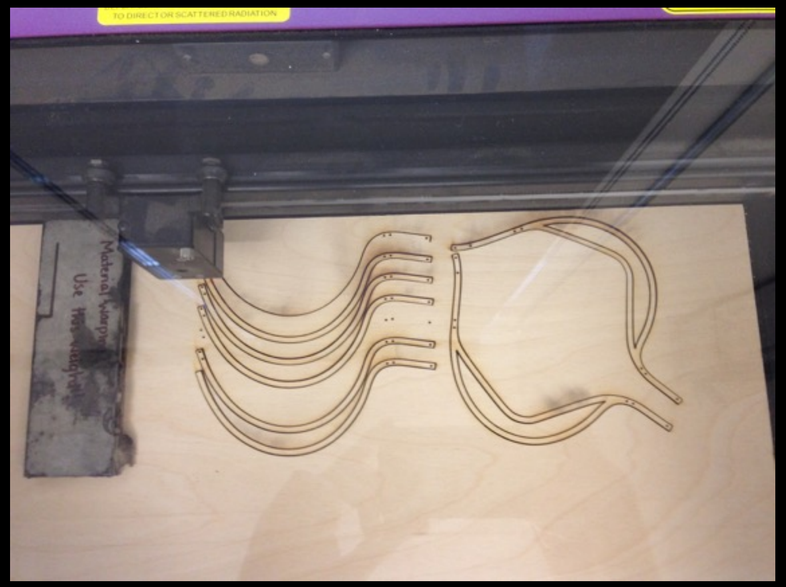


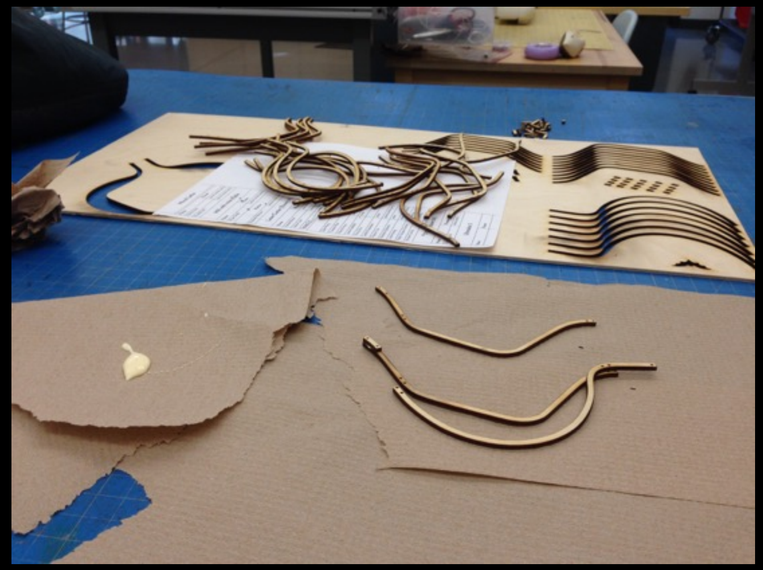


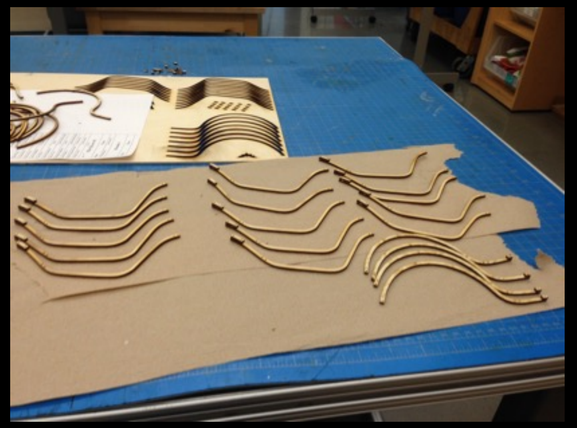
While these pieces would fit into 2 4x8 plywood sheets, when divided into 4x4 panels, a fifth was required, meaning I needed more material than my constraint allowed. Given that this was a function of unusual equipment (most wood CNCs have beds of size 4x8 or 5x10) I allowed this to slide.

I also added two guide holes anywhere two pieces would meet. These guide holes, when cut through, would allow me to stick wood dowel pins between layers for greater structural support than just glue alone. These had the added benefit of making it easy to align my pieces perfectly.

SMALL SCALE MODEL



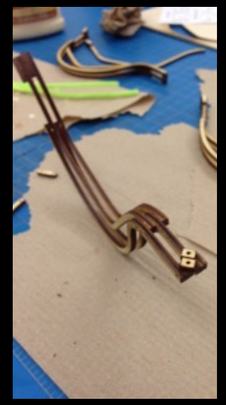


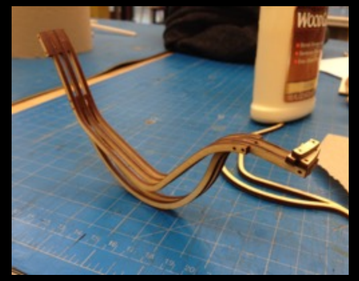


I laser cut a small-scale model of my final chair design.

The purposes of this experiment were to better understand the order of operations in assembling (gluing) each of the final pieces and also to know how well the final chair would balance in its unoccupied state.

Rhino has a feature command called VOLUME CENTROID that will calculate the center of gravity for a solid, so I was fairly confident that the chair would sit balanced, but I wanted to be sure.



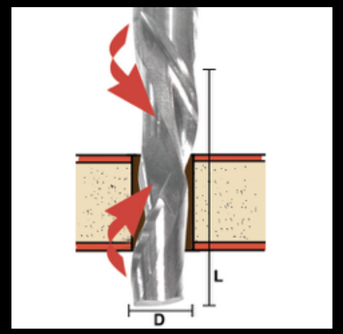


SHOPBOT LEARNINGS

UPCUTTERS, DOWNCUTTERS AND COMPRESSION BITS

I quickly learned that neither upcutters nor downcutters are ideal for cutting completely through plywood. Each one leaves an unclean edge that may chip away at the plywood surface (if laminated) or else require significant sanding.

Compression bits, however, are perfect for this task. They are a hybrid upcutter & downcutter.



One important thing to note: because compression bits have an upcutter at the end, their initial plunge must be greater than the length of their upcutter to ensure a clean upper surface.

I experimented with a number of settings for the Freud 77-202 1/4" Double Compression Bit I purchased on Amazon.

With the alpha shopbot, these settings seemed to work best for cutting through 3/4" birch plywood:

80 IPM @ 10000 RPM
.375" FIRST PASS
.375" (OR SMALLER) SECOND PASS

At a feed rate as slow as 80 ipm, making more than two passes was not necessary (and would take unnecessarily long).

That being said, make sure to wear hearing protection as the tool at these settings is quite loud and squeaky. It does not, however, get hot to the touch and should not burn your material.

For 3/8" holes, I would suggest three passes. Ensure the first pass is .375" or greater.

DO NOT ATTEMPT TO USE THE 1/4" TOOLPIECE TO DRILL 1/4" HOLES!
My original design used 1/4" wood dowel pins to connect the pieces. I was not successful in using my compression bit to drill holes 1/4" in diameter without burning my material and damaging my bit.

REDUCING SLIPPAGE

With the pieces you are cutting nested so close to each other, I recommend that you create a toolpath of shallow guide holes ("pockets") that indicate where to drive the nylon plastic nails with your pneumatic nail gun. This will better fixture your pieces to the work surface, allowing you remove them more cleanly afterwards.

As sacrificial material to lay beneath the plywood, I recommend tempered masonite at 1/4" or greater thickness. The masonite lasts much longer than the untempered duron available for sale at the PRL and the thickness makes it easier to pry your plywood off of the work surface without accidentally popping out or damaging your pieces.

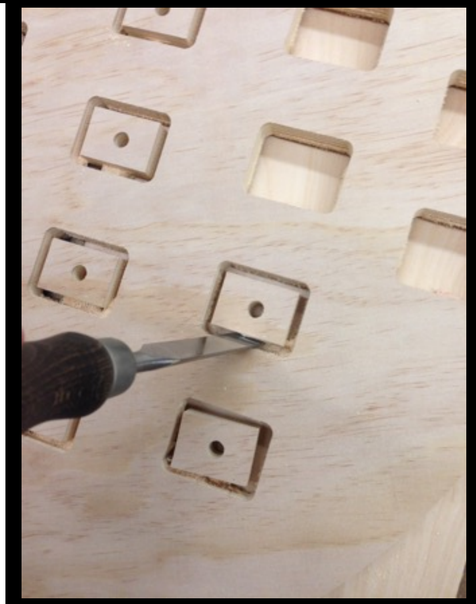
FABRICATION

Cutting time was generally <1 hr per sheet.

I needed to cut 5 sheets. There was about 30 minutes of prep time in-between cuts during which I set up the work surface and reset the shopbot.

YOU CAN CUT ALL THE PIECES IN ONE LONG DAY.

FABRICATION (CONT.)



It is recommended that you cut tabs every couple of inches along the edge of each piece. This prevents the pieces from slipping out of the sheet and damaging themselves and/or your toolpiece.

VCARVE makes adding these tabs easy. Keep in mind that you want enough tabs that your pieces stay in place, but not so many that they become a hassle to remove.

For the larger pieces I recommend tabs that are 1/4" thick. These can be easy removed with a flexible Japanese hand saw (pictured). Take care not to place these tabs along curves as then they are harder to remove and will require additional sanding.

For the smaller pieces I recommend tabs that are 1/8" thick. These you can remove with a sharp chisel and hammer.

GLUE-UP (DRY RUN)

After your pieces have been removed, I recommend that you sand them thoroughly, especially around where the tabs used to be. Sanding is more difficult after assembly. The technique indicated here worked well.

Since the 3/8” dowels are 3/2” in length, they are almost exactly the width of two pieces. That means that when stacked together, the dowels may sit flush against the piece. this is not good for the structural integrity of the chair. I created the jig on the right to quickly and equally shorten the dowel pins with the belt sander.

GLUE-UP

I recommend Titebond III wood glue and a FastCap Glu-Bot or Babe-Bot (pictured) for application. Remove pieces from one end of the dry-run assembled chair and start gluing them on a large open workspace. You can use clamps or ratchet straps (pictured) to apply even and sufficient pressure.

My glue dried in less than 2 hours and thanks to the structural support offered by the wood dowels, the chair was all ready for a test sit!

BILL OF ITEMS

MATERIAL	COST	SUPPLIER
3* SHEETS OF PINE▪ PLYWOOD	$105	HOME DEPOT
1 BOX OF 200 3/8” WOOD DOWEL PINS	$20	AMAZON
TITEBOND III WOOD GLUE	$10	AMAZON
TOTAL	$135	

*ONLY 2 SHEETS ARE NECESSARY, BUT EXTRA MATERIAL IS RECOMMENDED

▪CAN BE SUBSTITUTED FOR THE MORE EXPENSIVE BUT EASIER TO FINISH BALTIC BIRCH OR APPLEPLY (BOTH AVAILABLE AT MACBEATH HARDWOODS)

END RESULT

SPECIAL THANKS

TO JOHN EDMARK AND MY FELLOW CLASSMATES, ESPECIALLY THE PRL TAS


KYLE DUMOVIC