

PVC & Cardboard Shelves

Aidan Morales 12/14/2020

Problem Definition: Shelf to organize tools and materials

Primary Functionality:

- Organizes everything neatly
- Can support load
- Stays out of the way/no clutter

Secondary Functionality:

- Hooks to hang tools off of
- Extra space to hold cosplays
- Looks nice (least priority)

Thoughts:

- Would free up lots of space in my closet/make me more organized
- I have lots of extra materials from moving/props
- Has to hold a lot of weight, heaviest stuff will be at the bottom

Research of existing solutions

Cardboard Technique

- A lot of cardboard construction videos revolve around stacking multiple thick layers of corrugated cardboard together
- I do not have the type of cardboard used in these videos, would have to stack more layers together



Commercial Usage

- Target sells storage boxes made of cardboard and canvas
- Are meant to be used with the holes at the top but can support a lot of weight regardless
- Used to have these in my house and would use them to store a ton of books
- Can't stack to make a standalone shelf, though.



PVC Shelf

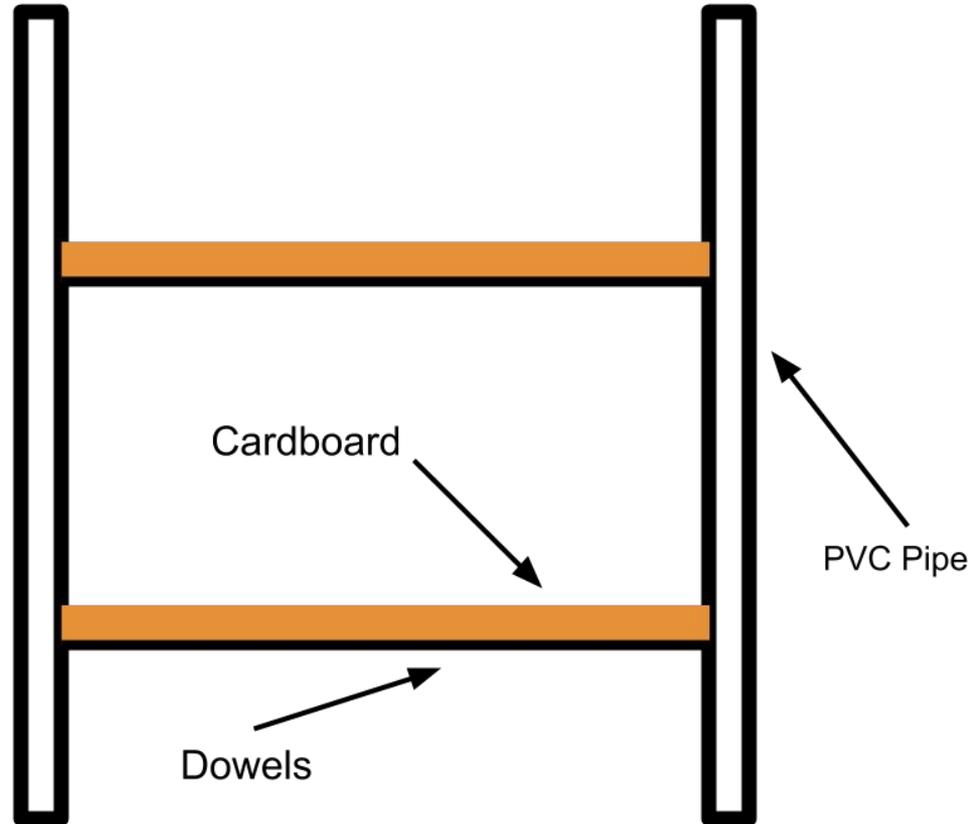
- Sturdy enough to hold materials
- Might be unstable/wobbly, would need to be connected to the wall or made stiffer



Totally good drawing of what the shelf will look like

List of Possible Materials

- PVC Pipes
- Dowels
- Cardboard
- Foam (?)
- Hot Glue
- Wood Glue
- Super Glue
- Screws (?)



Takeaways

- Shelf will have to be sturdy enough to support a lot of various materials
 - Most materials are light (foam, paper, etc.) but there's a lot of it
- While aesthetic is of the least priority, I want it to at least look and be usable so that I don't end up throwing it out a few weeks later
- The lack of a wood shop is gonna force me to be creative with how I assemble things
 - I might have to pick up more boxes or materials from Michaels

Designing

Aiden makes

Cardboard & PVC shelves

Primary Function:

1. Organizes materials/tools neatly
2. Supports a large load
3. Stays out of the way/no clutter

notes:

1. Consider holes for tools?
2. Find way to strengthen rather than use materials

Constraints:

Size: no larger than ~~3~~ 3 ft x 1.5 ft x 6 ft

Weight: must support weight of foam, glue, paint, tool, etc.

Units Supported: Enough to free up space in closet, not all if necessary

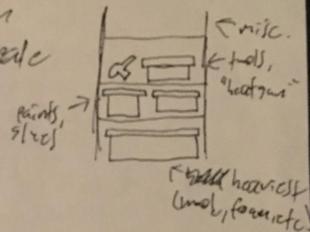
Materials: leftover cardboard, dowel, PVC pipe

Key Features:

1. Labeled shelves/bins

- boxes made from cardboard and lot glue
- heaviest items at bottom

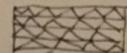
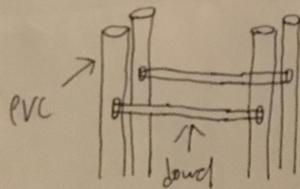
Especially int. mostly on me to create a storage/labeling system



2. Supports load

- use of reinforced/~~labeled~~ layered cardboard
- multiple sheets of cardboard per level

Where to source cardboard? How to drill holes in and cut PVC and dowel?



multiple sheets of cardboard on top of dowel

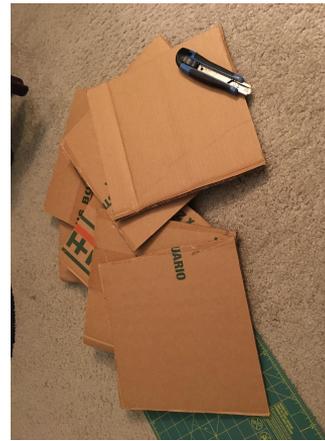
Prototyping

Phase 1 Prototype

- Last time, I used scissors to cut cardboard. While it works, it's very difficult, and I can't get much leverage. I learned my box cutter is better... cause it's a box cutter..
- I liked the sturdiness of the design so far, even though I'm not cutting rectangles and gluing them parallel.
- I'm not going to use tape to hold the shelves together. Hot glue is hard to work with on big surfaces, but tape is annoying to work with.



Step 1



Step 2



Step 3



Step 4



Final shelf prototype.
Three layers of
corrugated cardboard.
Will test by placing
between two chairs and
putting weight on it.

Purpose of Prototype

- To test the sturdiness of the shelf design.

Testing Process

- Simulated Test
 - Placed the shelf between two chairs 10 inches apart
 - Added weight in the form of 500 g water bottles and two 3 kg water jugs (minus weight of plastic and cardboard).

Results

- The shelf could hold a total of 18 kg/~40 lbs, possibly more, with little stress.



Aspects of the Design I Liked

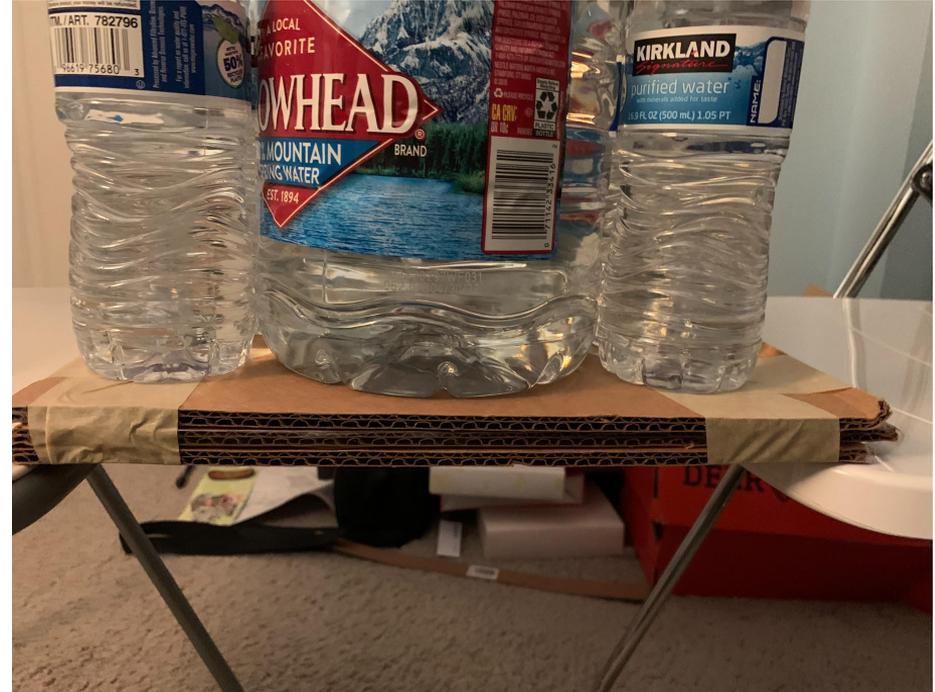
- I liked the sturdiness of my design. It barely bent at all and showed no sign of bending until I put my weight on it.

Aspects of the Design I Disliked

- I don't like how uneven and ugly the shelf looks. I'll have to find a way to cut the layers even. I also have to find a way to glue the layers together so they're one piece.

Plans for Improvements

- I'll probably cut the cardboard sheets with a band saw or using another sheet as a guide. Maybe using stronger slow drying glue would also help as well.



Rough Draft

Building

Something I Learned

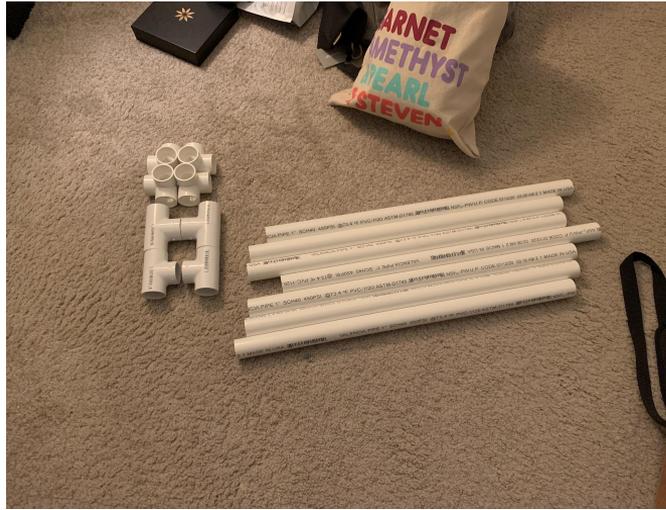
- PVC cutters are a LIFESAVER compared to the circular saw or band saw.

Something I Liked

- The design is simple to build and uses less PVC.

Something I Will Not Do Again

- The joints need to be glued. I didn't glue it cause it's a rough draft, but it's not that stable.



Materials:

- 7 1" x 2' lengths of PVC pipe
- 4 weird 90 degree bends with the thing coming out the top
- 4 T joints

And 1 PVC cutter

The PVC was cut into 14 1' long sections. I also cut extra cardboard (not documented cause I forgot) since the cardboard pieces from the shelf design was too small.



Testing

Key Features

- Testing the support frame and seeing if two sheets of cardboard is enough.

Simulated Testing

- Placed water jugs on shelves, moved shelves slightly to test stability

Results

- Both shelves could hold the 6 kg/~13 lbs water weight (two jugs).
- Shelves rocked too much for comfort no matter where the heavier weight was placed (top or bottom).



No bending of the cardboard or the PVC pipe! However, due to either the design of the frame or the lack of glue, the pipe frame twists and is very unstable for something that will be several feet tall. I'm not exactly sure why this is since the rungs on the first level are supposed to prevent this.

Evaluation

Liked

- The frame was simple and easy to assemble.
- It held the load very well and showed little stress.

Didn't Like

- The frame rocked too much, even when slightly pushed.
- There are no attachments between the shelves and the frame, and it looks ugly.

Improvements

- Permanent attachments with glue.
- Make it look cleaner.
- Prevent rocking through cross bracing or making it impossible through design somehow.

Final Iteration

Iteration 1 - *Frame Stability*

I chose to focus on this area because

- I wasn't happy with the amount of swaying and twisting in my first prototype.

My approach

- I used a rubber mallet to make sure each PVC joint and pipe was snug. I also added a rectangular base at the bottom to prevent bending. No glue in case I need to make changes.

The results

- Even without glue, the entire design is very stable. It doesn't move as much as prototype one.



Iteration 2 - Shelf Attachments/Sturdiness

I chose to focus on this area because

- The temporary shelves on my first prototype were made from scrap and didn't look nice, nor were they attached at all.

My approach

- No zip ties or drilling yet in case of changes. Instead, I cut two glued cardboard sheets to form fit around the pipes and joints so they wouldn't move side to side.

The results

- They hold well even without zip ties, and they don't move. It's actually a tight fit.



Iteration 3 - *Shelf Aesthetic*

I chose to focus on this area because

- All my shelf designs have looked ugly since aesthetics was my lowest priority.

My approach

- Glue two pieces of cardboard together and draw a shelf design on top. Cut out of glued sheets using a bandsaw for cleaner cuts.

The results

- Very neat and clean looking shelves. The band saw was also easier than a box cutter and allowed me to make the curves around the pipes.



Project Functionalities

Primary Functionalities

Organizes Everything Neatly

- Yes, but this falls more on my organizing skills than engineering skills. However, there is plenty of space to hold a lot of stuff in my closet, allowing me to free up space.

Can Support Load

- Yes, the shelf designs are the same from before, and they can hold a lot of weight. However, it does bend in the center. The load will be evenly spaced, though.

Stays Out Of The Way/No Clutter

- Yes, the shelf is measured to fit between my dresser and door.



Secondary Functionalities

Hooks To Hang Tools Off Of

- No, as there is no large surface to put a command hook. I can just place tools on the shelves.

Extra Space To Hold Cosplays

- Sort of, there is space for me to put boxes for my cosplays underneath.

Looks Nice

- Yes, I specifically used this method of cutting the shelves and hammering the pipes to make it look neater.



Concluding Thought

Project Reflection

Aspects of my project that I like

- How clean and sturdy it looks now.
- The amount of weight it can hold.
- The lack of movement.
- The simple design.

Aspects of my project that were difficult

- Getting the PVC joints and pipes to line up as to prevent twisting.

What I would do differently next time

- Glue and zip ties for the pipes and shelves.

