Building a Budget Gramophone

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This semester, I took my frugal nature and my love for the vintage in an attempt to build a gramophone from scratch. The caveat of this project was mainly that I wanted to do it for less money than it would cost to purchase a new record player. I became especially inspired to work on this project over my other ideas for a couple reasons; the inexpensive cost of used records alongside my already growing collection as well as growing up with a jukebox in my house and always having been exposed to vinyl. Overall, I spent most of the lab work times on dealing with minor design setbacks and qualitative testing, and a portion outside of class on construction, material acquisition and art department facility use.

My first order of business was to see just how cheaply I could create a gramophone. Doing some light research online yielded some surprisingly simple results. Using nothing more than some cardboard, a sewing needle, a piece of paper and a plastic screw, I formulated the first version of my gramophone. Costing a mere 20 cents for materials and a measly 15 minutes of creation time, this would surly become the cheapest and quickest iteration. This, however, did come with its share of downsides. One major one was that no motor was included in this design, and as a result a manual spin was required in order to maintain record motion. This of course was difficult as spinning a record by hand at a constant (not to mention correct) speed is no small feat. Another issue is that the use of a sewing needle isn't good for the vinyl record. Generally needles are made of soft metal that allows the sound waves to vibrate throughout it, which will contribute to making the sound. The hard metal sewing needle wears away at the record grooves and thus slowly damages the record over time. However the biggest problem with this design was that the sound that came out of the horn was near indistinguishable. After the initial amusement of listening for sound wore off, we started listening to the record itself. I had purchased a complete recording of Handel's Messiah for a mere dollar for testing, and the

Earliest iteration of the Gramophone

most we could distinguish from this player was whether a woman, man, full choir or orchestral music was being featured in whichever part of the song. Despite this, it did provide a framework for what could be accomplished on a tiny budget, and so any improvements from this point could be referenced back.

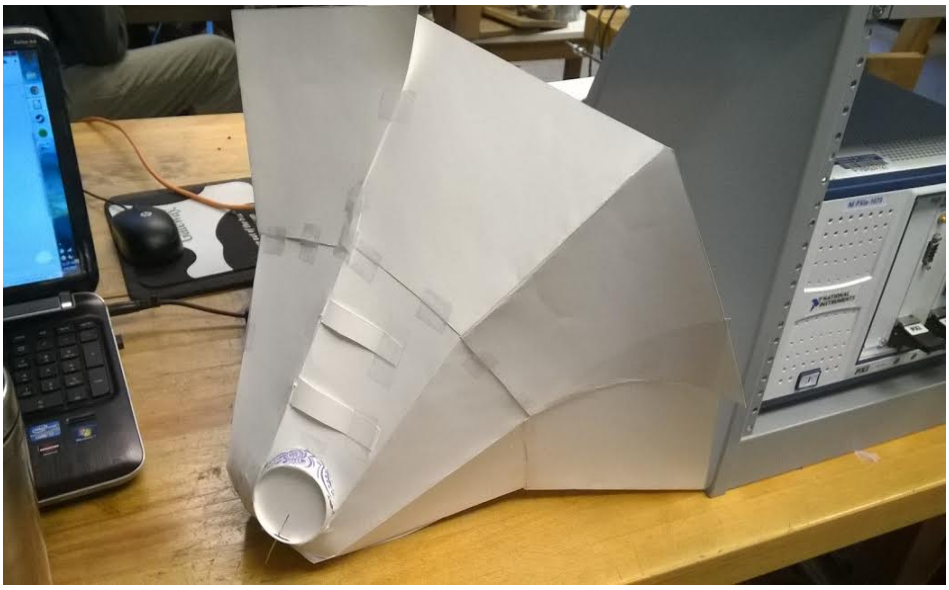
The next step was to pick a design to work towards. The options of budget gramophones online were pretty slim, and I quickly settled on the aesthetically pleasing Jonofon, created by Icelandic designer Jón Helgi Hólmgeirsson. This piece used plywood, card stock, simple electronics and a cup and needle combination that created a completely working record player. Videos (https://vimeo.com/49558340) showed the machine working very well and distinguishably, however for materials being as simple as they were, it was priced at the near-unreasonable cost of $120. Thinking I could create a similar piece for much less, I emailed the designer, who responded with (loose translation) “feel free to mock the design, but don't resale”. Since pre-orders for the Jonofon are just becoming available, restrictions on the design were not finalized, so I was able to use it as a rough springboard for my own design. The Jonofon excelled at simplicity, but had its own fair share of problems. The main one was that the fact that the horn rested on the record caused considerable pressure on the record itself, and that

continued use would eventually cause wear on the vinyl. With this design as a backbone, I set to work on component testing and combining.

Credit: Héðinn Eiríksson

The first order of business was to do some qualitative testing on the components that allowed the sound to be played. The materials used for the Jonofon show a paper cup attached to a needle that rest on the record player. Wondering if this would be the best, I ordered several gramophone needles, which promptly came, and tried them out attached to various cup types. In essence, this is the same physics that makes the tin can telephone work; the vibrating bottom of the can is caused by the vibrating string, or in this case needle, and turned into a speaker to create sound. I tried this testing with several materials: Styrofoam, thin plastic, paper, tin can and thicker plastic. The cups were placed onto the simple $.20 gramophone and tested for quality, distortion and amplitude. The most distinguishable sounds came from the paper cup, due mostly to its flat bottom that allowed it to work most like a speaker. The loudest result cam from the thin plastic cup though, and this was simply because it had the largest volume for which the sound to be amplified through. The necessity of a full horn became much more clear.

Next, the horn used to amplify the sound to reasonable listening levels needed to be created. This wasn't something that needed to be too original form the Jonofon design, as it's card stock horn is made to ship flat and be easily assembled, while maintaining structural integrity. In order to construct my own I simply invested in some card stock and drew a spiderweb-like design on it. I did a rough estimate of the dimensions, however this wasn't difficult since having the horn a specific size didn't matter as much as just having a larger cavity for which the sound to go through. One of the small sides of the octagonal shape had to be able to fit a cup that was cut down for this purpose, so the starting measurement was made with a trimmed down paper cup that I had previously decided worked best. The result was a construction that was a little bit floppy, but easy to find a center of balance on and one that held the cup in place with relative ease. This design later underwent some minor revisions once the full gramophone body was under construction, however the octagonal shape ended up working just fine enough to keep through the end. The card stock, cup and needle investment totaled about $3.50.



First iteration of the horn

The next step was to tackle the actual body of the machine. This was essentially divided into three main parts: the base for the electronics and everything to lay upon, the turntable to rest and rotate the record on, and the arm in some form. While the arm in the original design was simply the entire horn, I wanted to create an alternative solution that put less pressure onto the record itself. There were a couple of ways to approach this, but I knew that the turntable should be as round as possible, and so I wanted to remove human imperfections from the process as much as possible. Luckily, a roommate of mine worked in the art department facilities and recommended reserving time to use the laser cutter. In order to do this, I simply had to provide the material that had to be less than 1/4” thick and provide an illustrator file with the dimensions Since a record is very nearly a foot in diameter, the file we created called for a 12” diameter circle for the turntable, a 12” by 18” rectangle to construct the base, and two 2” by 10” rectangles for a potential arm. Since I wasn't sure which material would be easiest to cut into and work with, I had them cut three identical sets of these pieces out of different materials. I tried basic plywood, particleboard and a composite of the two, each of which were 1/4” thick and

The negative material from the particleboard cut

purchased from Menards, each for just about $4. Upon cutting all of them, the particleboard cut the most cleanly, and in addition it was the most lightweight which would later end up being a

benefit. It did have the disadvantage of being difficult to work with under a blade compared to the plywood, but this was something I was able to work around. The end result was a set of pieces with perfect dimensions and exposure to the art department's quality facilities. The total body cost with material and facility use was about $15.

With the body ready to be assembled, the next step was to get the electronics working. Luckily, I was thinking about this fact during my spring break, and was able to go a supply overstock store called Science and Surplus. Asking for their advice for a motor that would ideally rotate at both 33.3 and 45 rpm (the two most common speeds of records), I settled on buying a 20 rpm motor and modifying it using mechanical means. This particular motor was great since the exposed part of the axle was in a square piece of plastic, which would allow for an easier cut to be made into the turntable. Having very little circuit building experience apart from electronics kits, I used a very simple dc circuit with a 9 volt battery and switch. The problem then became how to modify the motor so that it could spin at the appropriate speeds. Again, the solution came in the form of art department facilities, but this time in the form of 3D printing. Using some simple conversion formulas for gear sizes as well as some parameters from the 20 rpm gear, I creates 3D files of the gears to print from the Makerbot Replicator 2 machine that they had most readily available. The motor itself is housed inside of a plastic casing, and since the new gears were smaller that the existing 20 rpm one, I was able to replace it with the two gears. Since the process of 3D printing will sometimes leave models with imperfections, I was happy when both of the gears installed and worked very well. The 45 rpm one in particular worked very well and smoothly. Once the electronics were ready, I cut a hole out for the plastic case in the 12” by 18” base, and a hole out of the center of the 12” diameter circle for the motor's axle. The other electronics simply hung from the bottom, and with more care for the aesthetic I may have moved/attached them to a different part of the base. This design did work very well, as

the motor spun very nearly at both the required speeds due to the lightweight nature of the particleboard. Some inexpensive foam was added to the top of the turntable so records wouldn't have to rest on the material, and a trimmed paper cup was taped to the middle for use of the larger centers of the 45 rpm records. The total cost for electronics and facility use was about $12.

The electronics underneath the base

3D printing the gears

The final and admittedly unforeseen problem came in the form of the arm. While I knew that I didn't want to put pressure on the record from the horn, I hadn’t come up with a solution by the time assembly began. I tried two solutions, each of which solved one of the two requirements that the arm needed to have. The first of which was similar to the original design, which involved a thin pvc that could move freely left and right due to a hole in another cup. This attempt let the needle follow the grooves due to its near frictionless movement, however it was very difficult to vary the weight that pressed onto the vinyl, and thus didn't have the volume required for easy listening. The second attempt was at using one of the laser cut arms, which was fitted with a bolt at one end and set atop a pvc connector. Being able to bend and angle the arm due to the bolt at one end meant the pressure and therefore sound on emanating from the horn was much better, but the weight of the arm on the pvc was far from frictionless. I tried a couple different iterations of these designs, however at the time of writing neither design is yielding a

playable result. The cost for these attempts are included previously in the body cost section.

A version of both arm attempts shown side by side

Overall then the gramophone is very close to being in working order. All of the individual components of it work save for the arm, and in addition the total cost was still under what I could by a new record player for. At $30.50 with materials and facility cost (excluding of course the university fees associated with tuition payment for these facilities), the goal remains intact, as a foreseeable future for this machine exists once a better arm solution can be generated. In spite of the product not working, I had the opportunity to garner a greater appreciation for vinyl and the machines that play it, as well as expose myself to the product development process and the machines that modern prototyping is accomplished by.

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