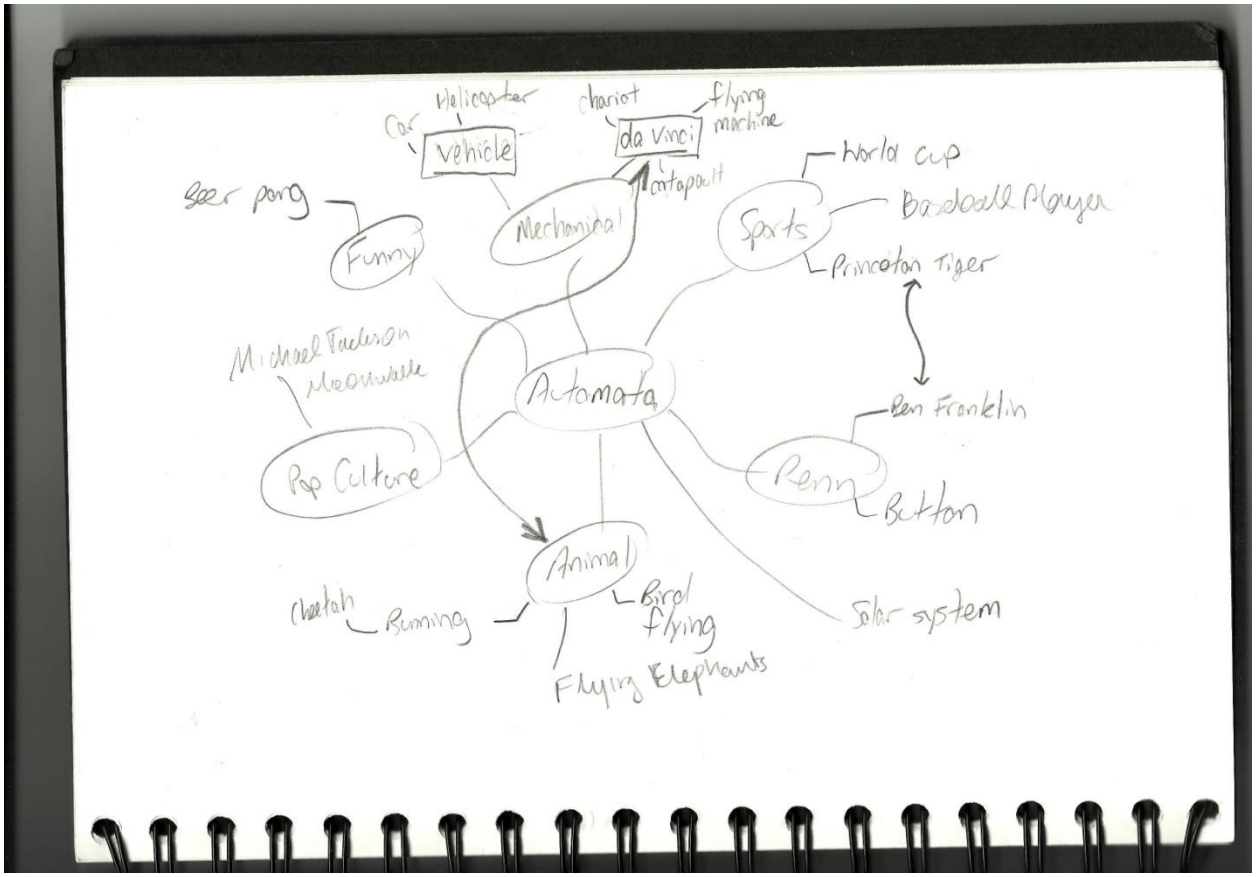
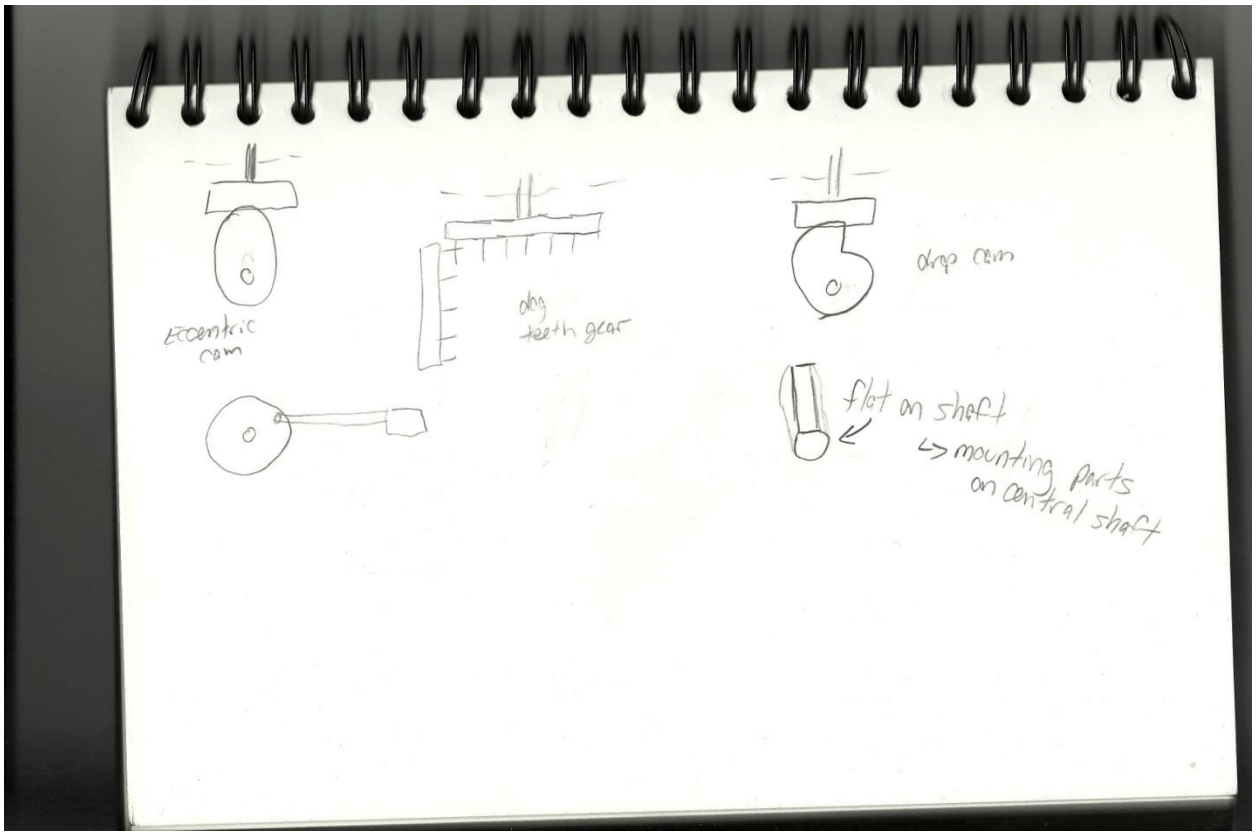
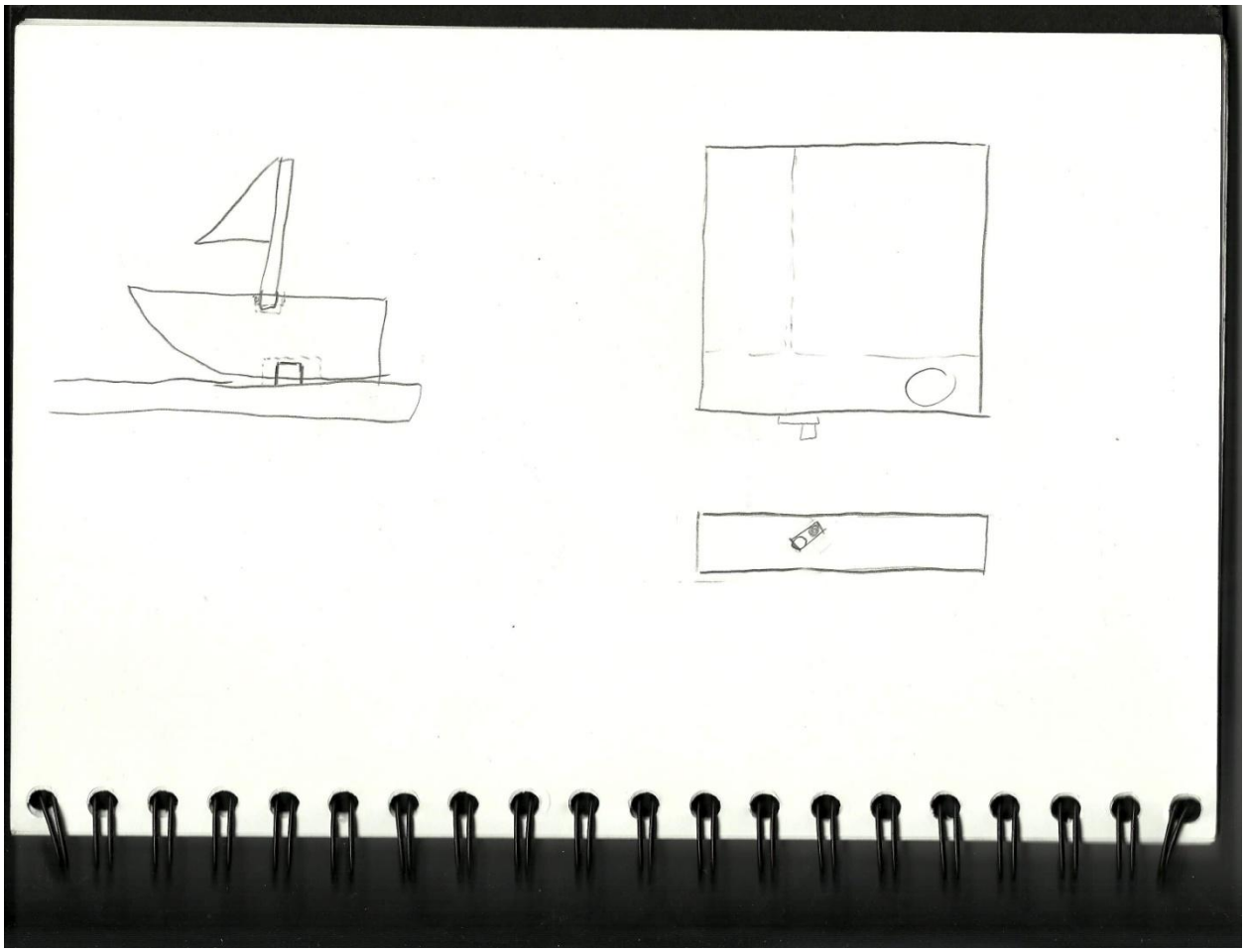


Brainstorming: Early on we decided on constructing an automaton. While this is a toy and not a game, it was decided that an esthetically interesting toy would be more intriguing than a game with few moving parts and a made up objective. Other discussion involved some sort of toy that involved gears or a game such as mousetrap or perfection but an automaton was unanimously favored among the group. Once the automaton was decided upon, the primary focus of our brainstorming revolved around choosing a theme for the automaton that would peak the interest of other Penn students and Penn faculty. Some of the ideas discussed are represented in the diagram above. There was also some discussion involving the mechanisms and work required to produce an automaton such as the different size gears and cams. Professor Fiene suggested D-shaped rods to act as the shaft in order to prevent rotation of the rods around the shaft.

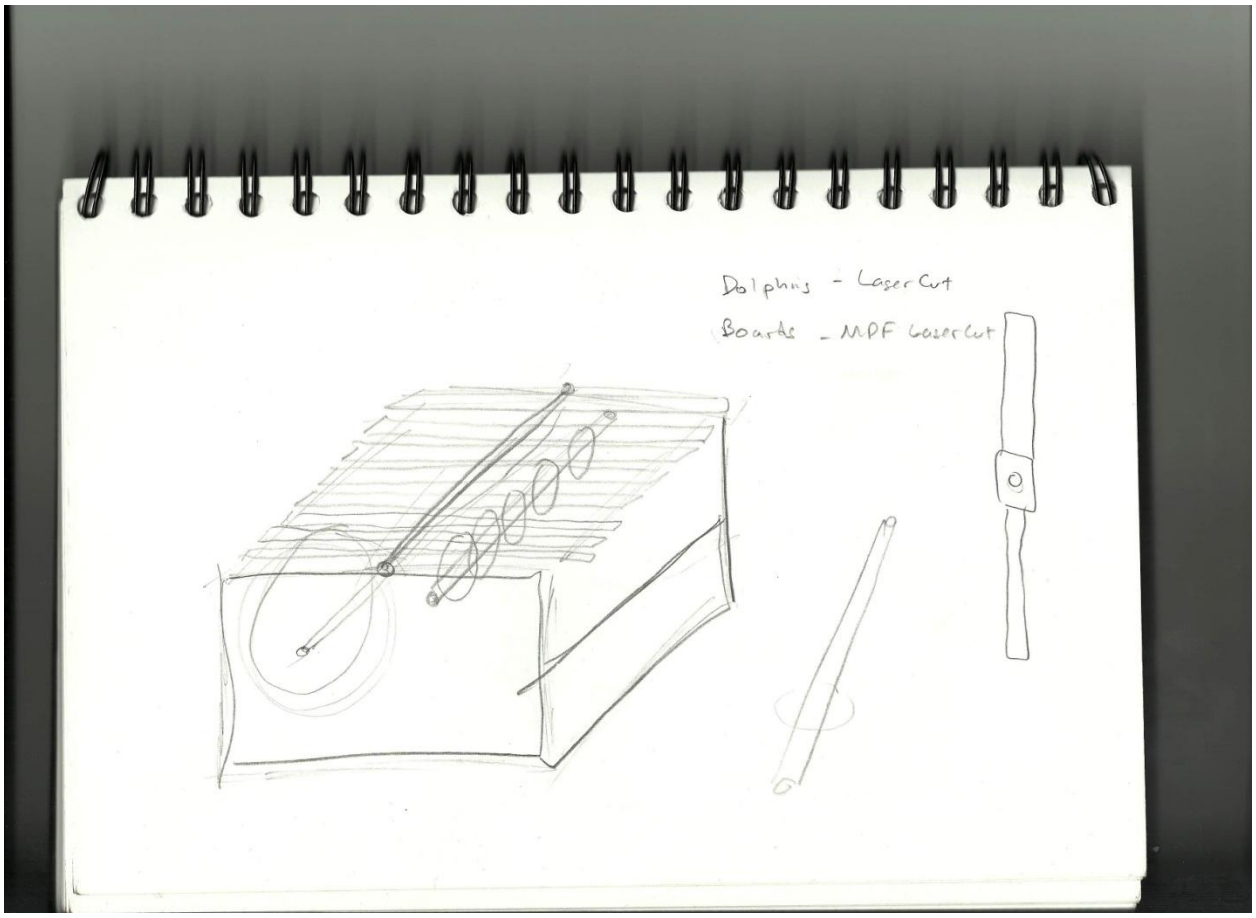
Discussion focused on theme of the automata. Group members agreed that something involving a wave motion would be aesthetically impressive. We also had our first meeting with Melissa, our MEAM 150 partner. She was confident her ability to produce one or more D-shaped rods, to prevent rotation of cams/gears, and to produce the rods such that the pieces could be screwed in place.



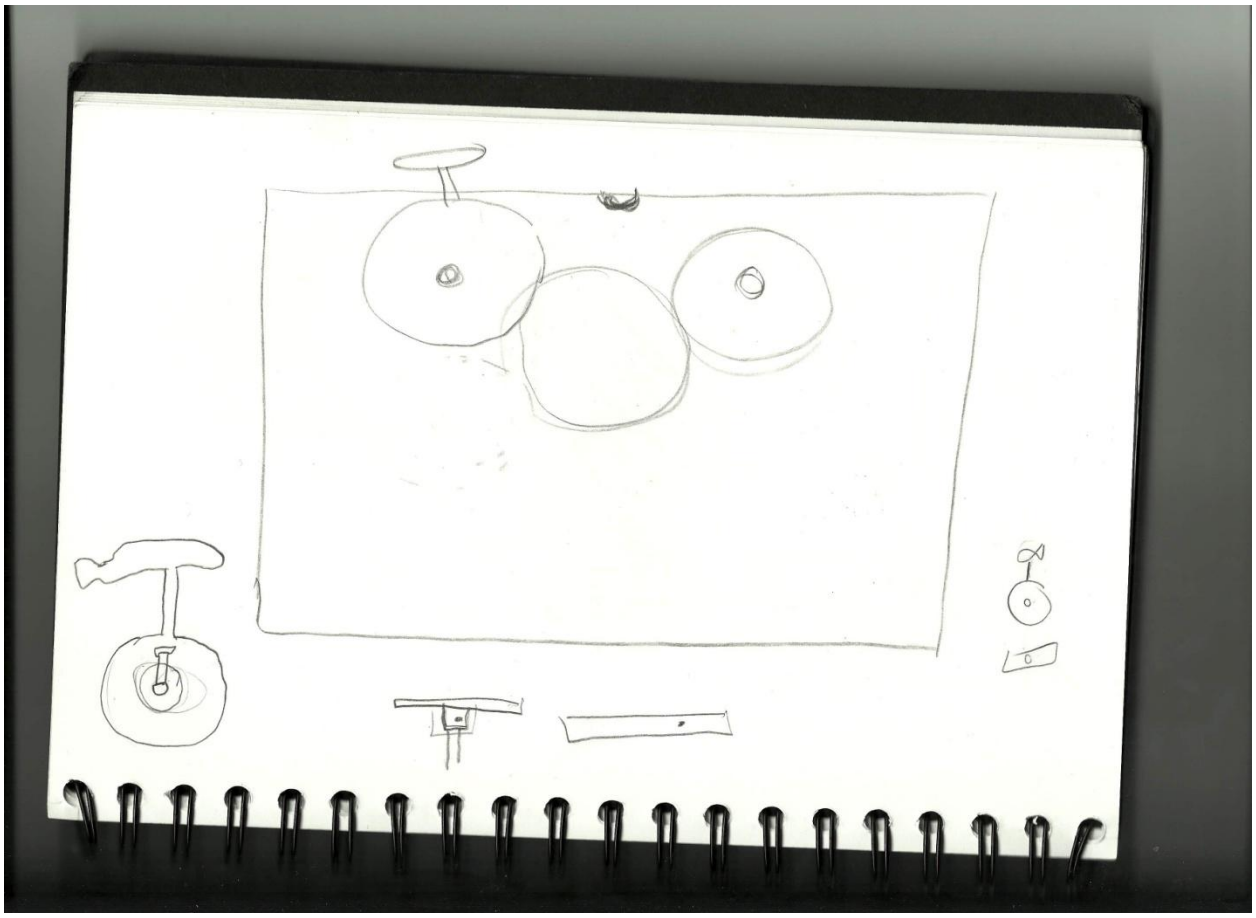
Mechanisms: The different motions we could produce by using different mechanisms were brainstormed. Some of these mechanisms were sketched above. Some possible mechanisms discussed included different types of cams, pistons, bevel gears, and crank sliders.



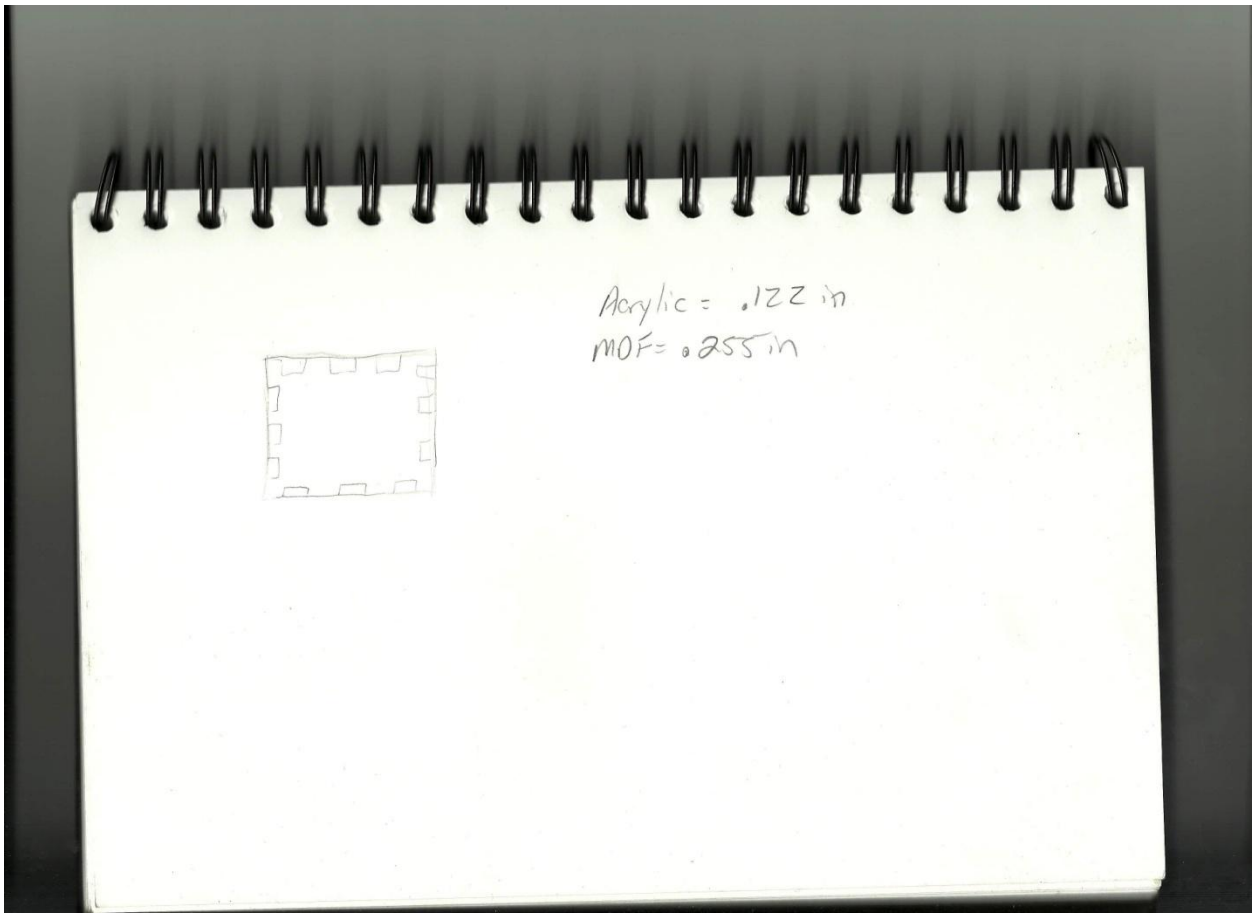
Concept: Automata of waves with a boat on top. Dolphins, or other such animals/objects, may also be added either between the individual wave components, or above the waves. It is likely that multiple gears, each with their own rod, will be turned by a single crank to move the various objects at different speeds. Waves will be moved by cams that are underneath and off-center. The boat will likely be attached with strings or a loose peg so that its motion can match that of the waves. Themes for the boat were discussed, such as pirates of the Caribbean.



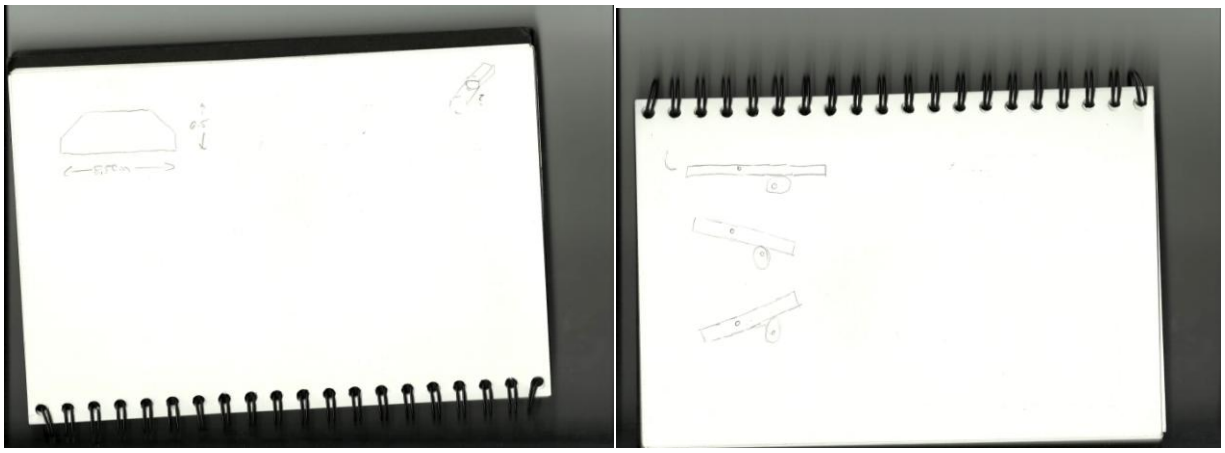
Method: Cams may be held in place through glue/rubber stoppers/screws/spacers. Other considerations discussed included attaching the rods to the gears and attaching the crank to one of the gears. Gears are to be laser cut, as metal tools at our disposal are not precise enough.



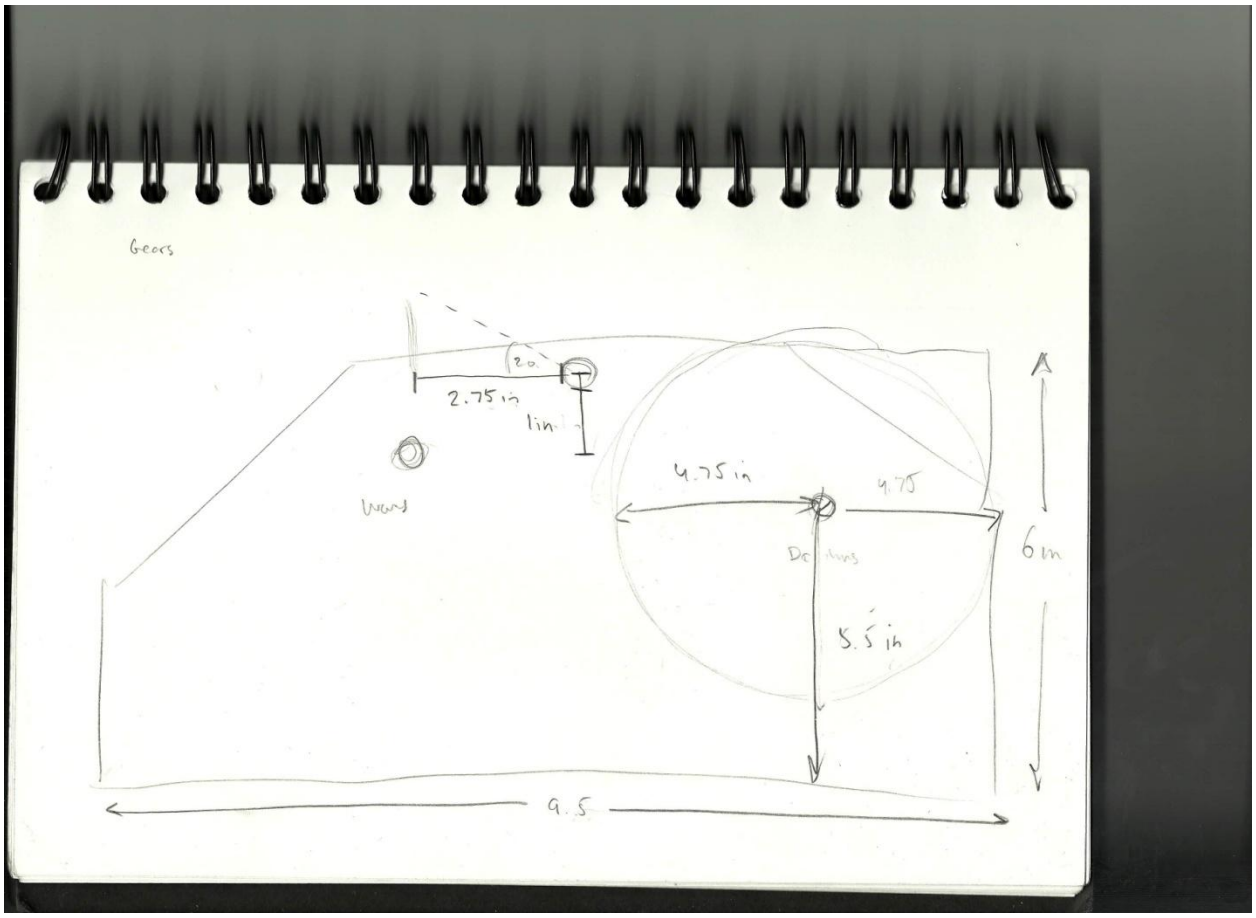
Design: We decided to leave the bottom open to display our mechanism. We also discussed spacers between cams as well as the possibility of having a lighthouse on a shoreline. However, we decided that there was not enough space on our model to incorporate waves and another moving piece without taking too much away from the waves.



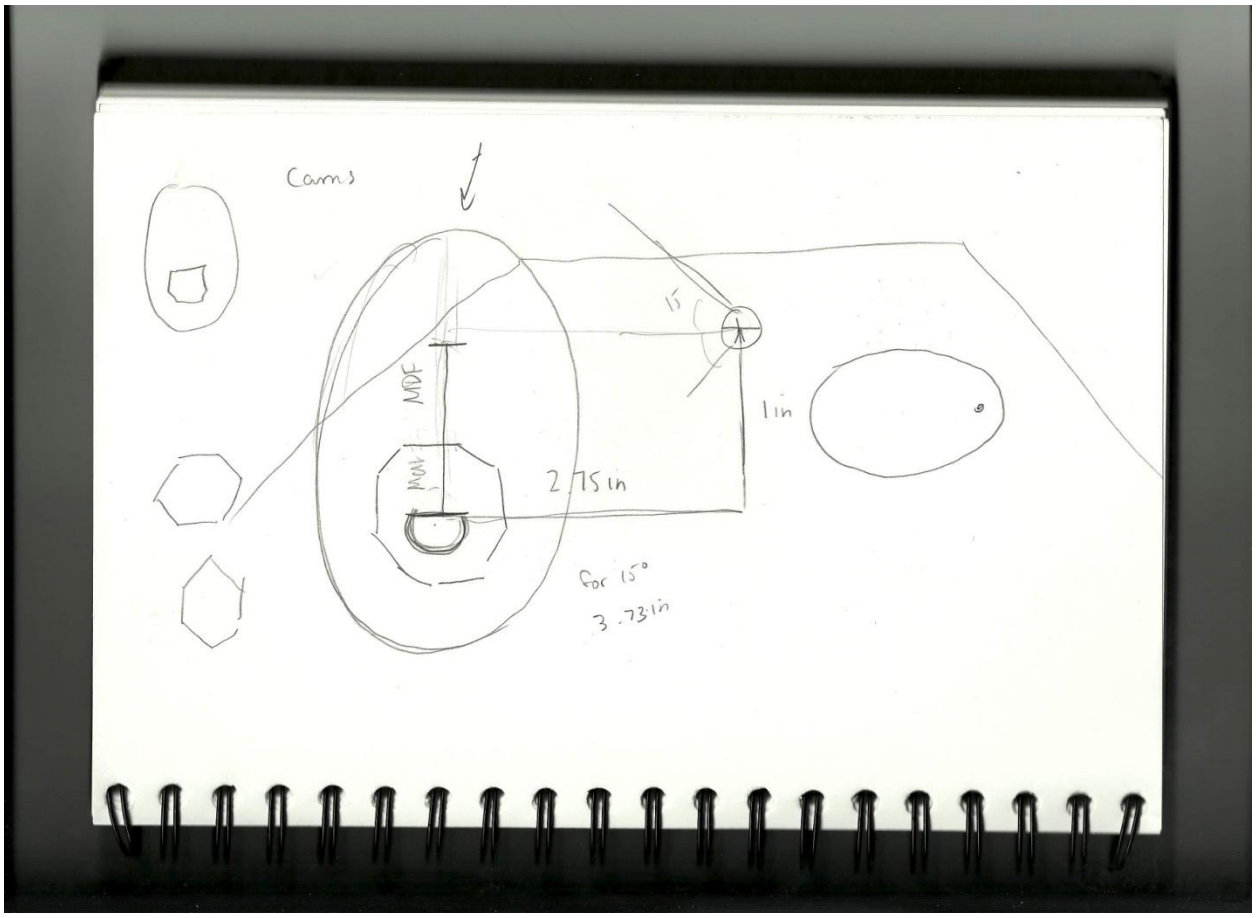
Press Fits: It was decided that the box would be constructed out of both MDF and acrylic pieces. The acrylic pieces would go on the side to display the mechanisms that drove the automata. The thicknesses of the materials were also recorded so that press fits could be accurately modeled.



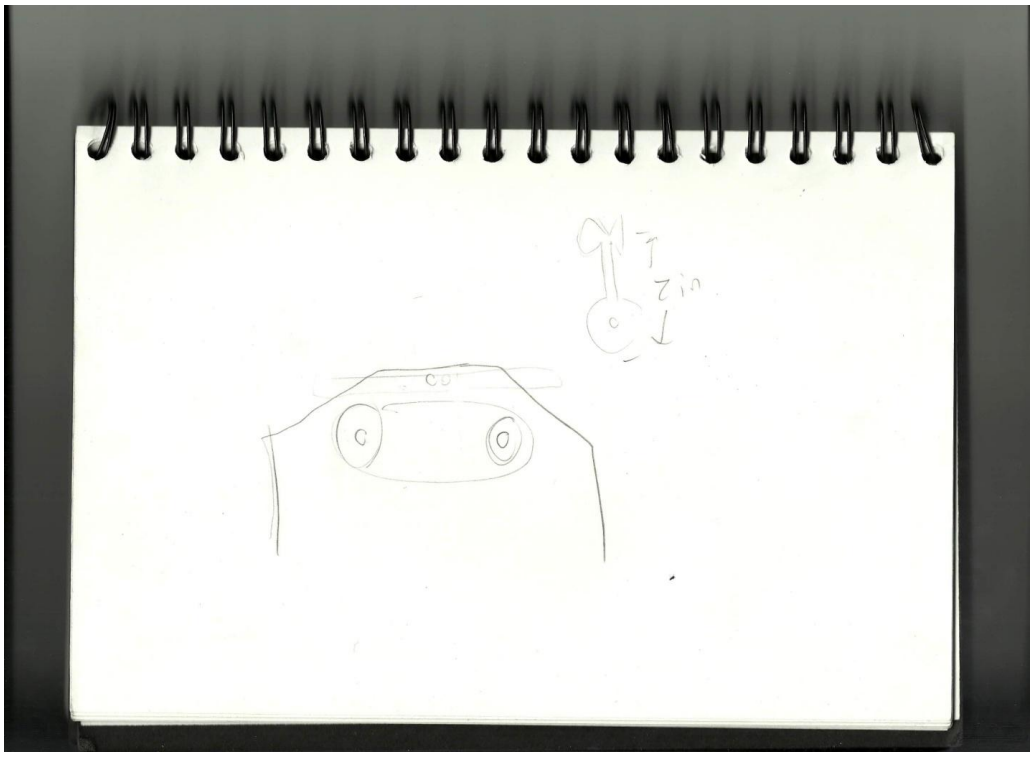
Cam mechanism: These were sketches that involved preliminary discussions regarding the mechanism that would drive the waves. We realized that the positions and sizes of the components would need to be roughly calculated so that the motion was even and none of the parts collided.



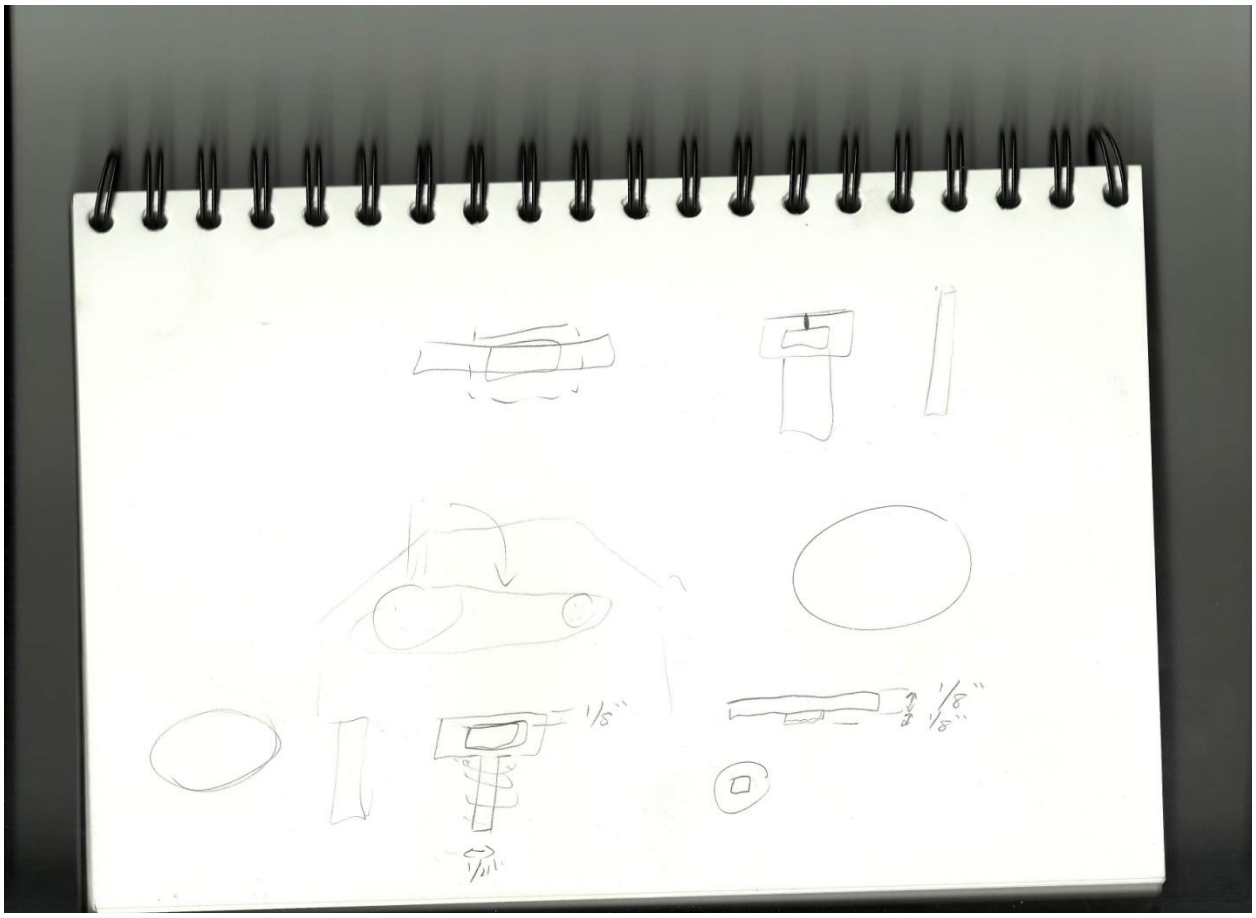
Calculations: First, we determined what we thought would be a reasonable angle for the desired maximum height of the waves. Then, we had to determine the placement of the cam-rod and central axle, as well as the size of the cams, that would give us the desired height. We also had to determine the placement of the dolphin-rod so that the dolphins would come above the waves at some point during their rotation, but not collide with the central axle.



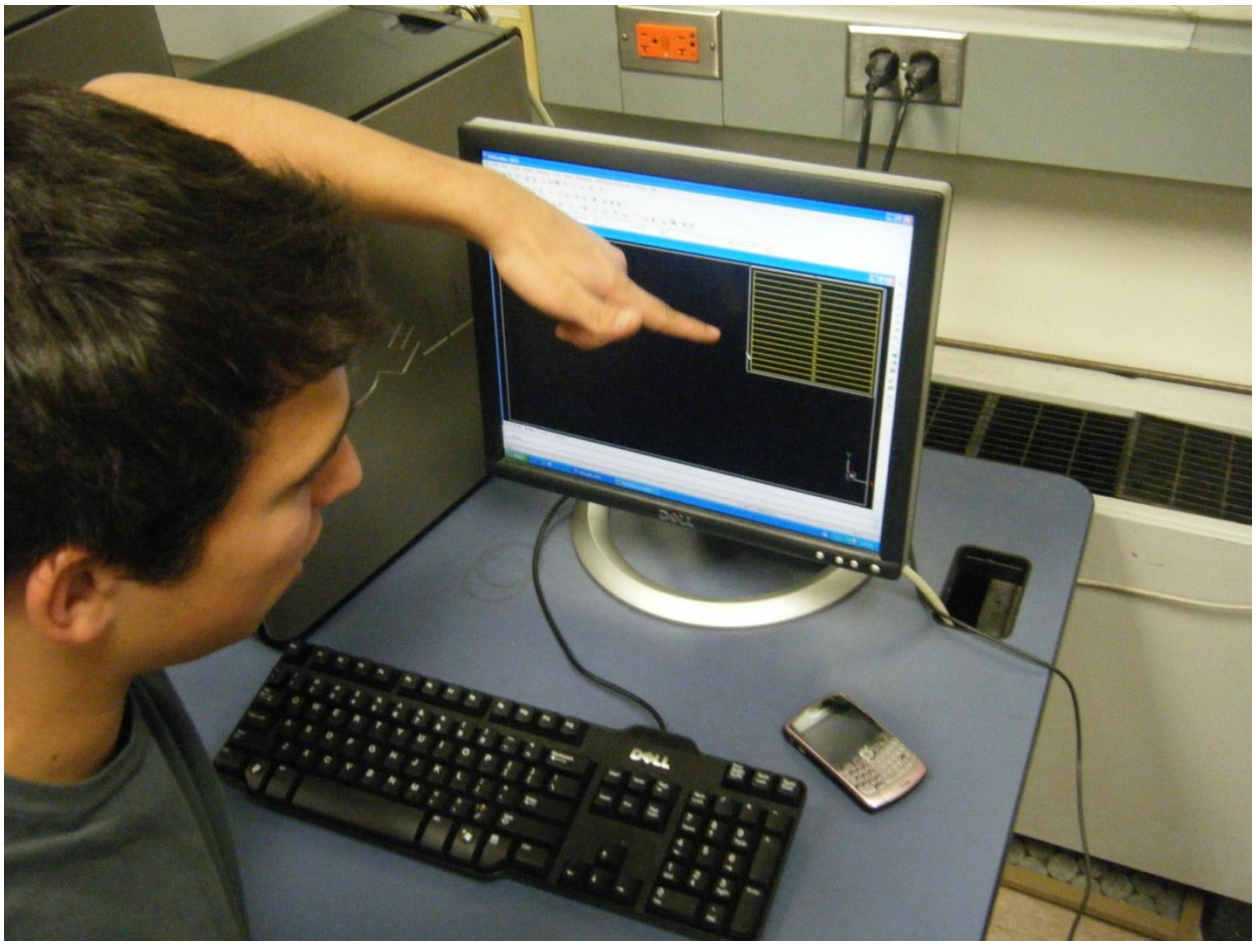
Cams: These sketches outline more detailed discussions regarding the cams. One of the most important ideas that came up during our brainstorming was the idea for some type of polygon-shaped hole in the cams and the corresponding polygon-shaped insert for them. Since we wanted a wave to propagate down the length of our automata, each cam needed to be rotated slightly from the ones next to it. Originally, we thought that we were going to have to create separate part files for each cam, with each file having a slightly rotated d-shaped hole. However, the idea for the polygon-shaped hole allowed us to manufacture identical cams and inserts and simply rotate the inserts when we placed them in the holes. A polygonal hole was deemed more favorable than a circular hole so that the rotation of each subsequent cam could be equal.



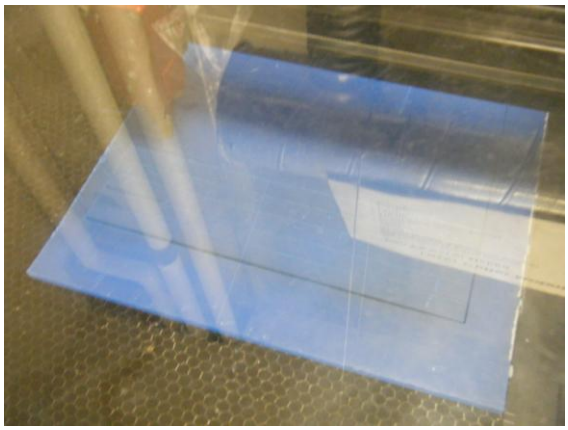
Pulley and Dolphin: We discussed possible methods for getting each piece of the automata to move using only a single crank. Our initial idea was to use gears made from the 3D printer. However, once the placement of the rods was determined, we determined that we would either make the gears very large or incorporate more gears. We felt that the large gears would take away from the aesthetic appeal of the model and that adding more gears would cause more possible sources for error. Ultimately it was decided that a pulley system would be the most effective and more plausible. We also determined that laser-cutting the dolphins from a single piece of acrylic would be the best course of action because it would be the most efficient and direct way to make them.

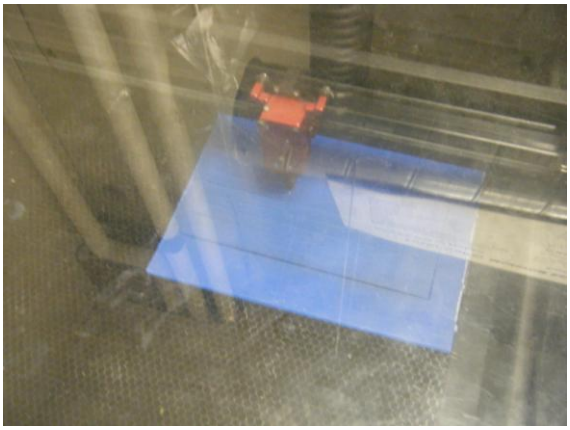


Crank and Pulley: Once a pulley system was decided upon, we had to determine how the crank would attach to the mechanism. Our initial discussions revolved around attaching a rectangular rod to the outer face of the large pulley and then creating a part with a hole that would allow it to slide onto this rectangular piece. However, this would result in a rectangular handle, which would be awkward for the user. Since the handle was the part of the model that the user would be interacting with directly, we continued to brainstorm other ideas. Eventually, we decided on having our MEAM150 partner cut a small piece off of our aluminum rod and using that as our crank handle. We attached a rectangular piece with a hole in it to the outer face of our larger pulley and we made sure that the hole was within the diameter of the pulley, or else the handle would interfere with the rubber band attaching the pulleys.

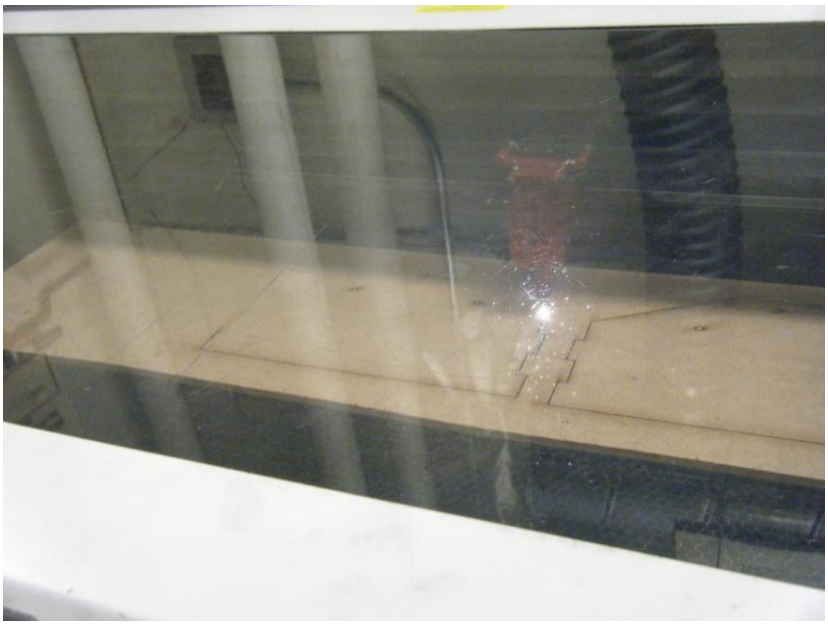


Making waves: Here, Matt explains how he created the laser-cutting file for the waves. The waves were packed closely together so that we would conserve as much material as possible.

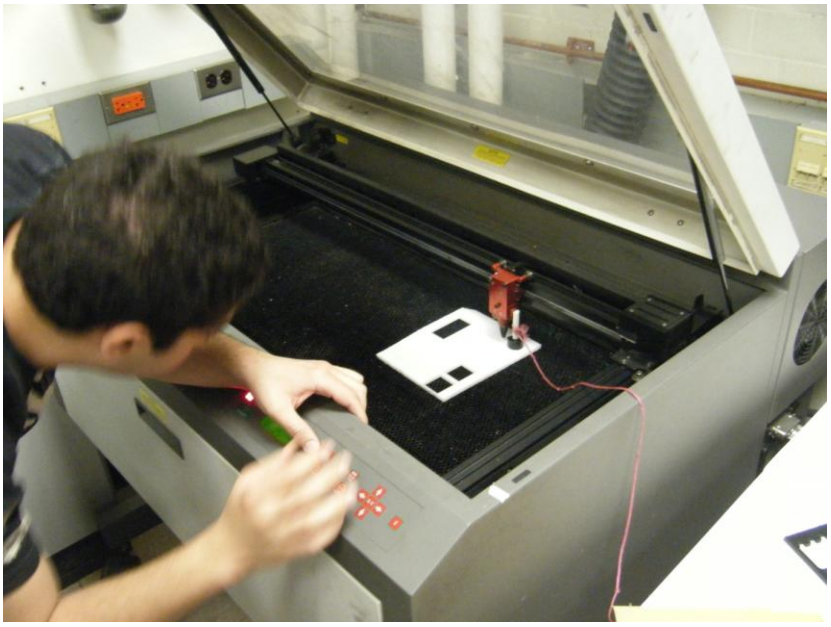




Modeling the Pulley: While Matt worked on the waves, Jonathan and Kevin discussed possible methods for making the pulleys. The issue was creating some sort of channel in the pulley so that the rubber band wouldn't slide off while in use. One idea was to print the pieces, but we were concerned with time constraints and the difficulty with remaking the parts if they were not ideal. It was determined that the easiest method would be to laser cut three separate circles (a smaller diameter placed between two larger ones to create the channel) and glue them together on the rod.

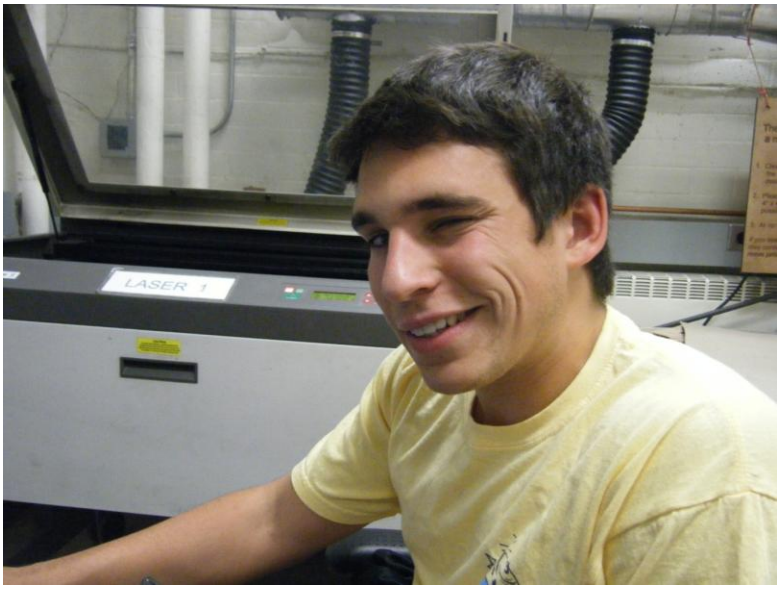


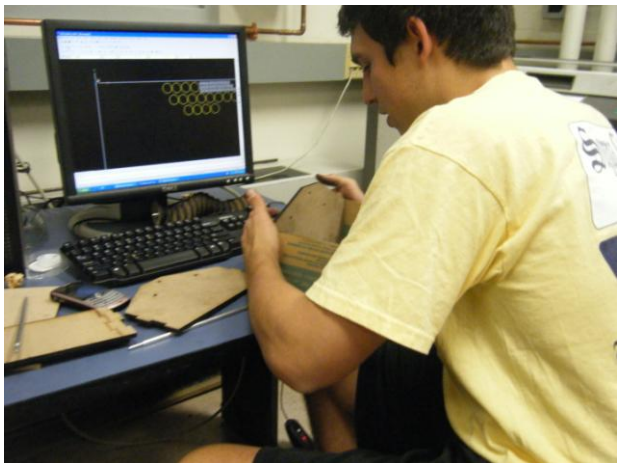
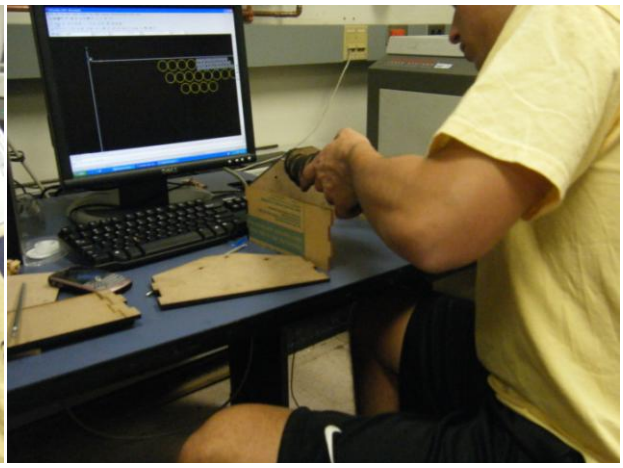
Piece by piece: Many of our parts were laser cut, so most of the group members gained valuable experience with the laser cutters during this project. As the project progressed and the group became more comfortable using the laser cutters, our manufacturing became more efficient. This was very important to completing the project on time, as the laser cutters were not always reliable or available.



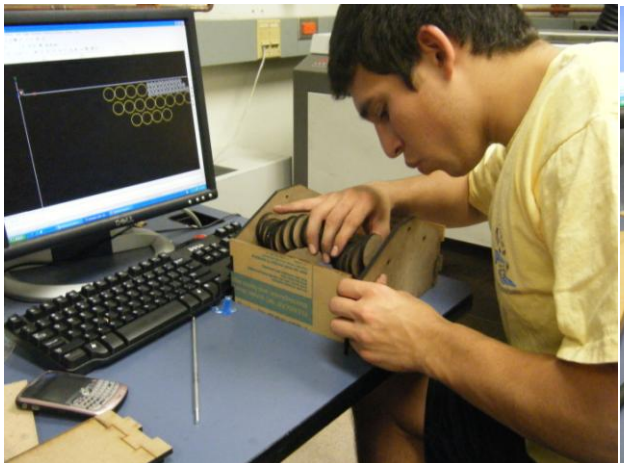
Starting to come together: The way the automata was modeled allowed us to create several iterations of a single part to create the main components of our project. The waves were cut with the hole slightly off-center so that they would be unbalanced on the rod and thus not lose contact with the top of the cams. The thickness of the material and the length of the model was planned so that we could use the same material for our parts as well as our spacers between them.

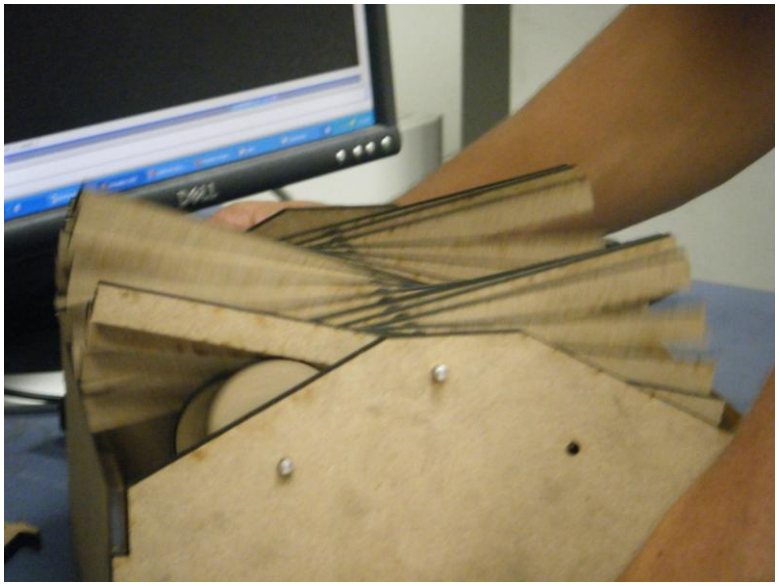
Aesthetic appeal: One of the most challenging tasks that we encountered was getting the aesthetic appeal of our project to match the aesthetic appeal of our group members. As difficult as that task was, we think we succeeded. Right, Matt?



A place for everything, and everything in its place: After all of the individual parts were cut, it was time to assemble the entire model and see if it worked.



Success!: Due to our thorough brainstorming, our automata worked as expected on the first try. We achieved our desired motion and all of the main components fit together as expected. Unfortunately, our camera was misplaced during the last few days of the project, so there are no photographs of the finished product. However, we considered the final project a complete success. Our finished model almost perfectly resembled our initial vision for the project, and very few changes had to be made along the way. On the day of the carnival, many people who passed by our table we enamored with the simple, yet captivating nature of our project, with many agreeing that it was one of the most visually appealing projects on display.