Northeastern University
College of Engineering

Cornerstone of Engineering I & II

DH Cornerstone Class

Rube Goldberg Challenge: The Design Process, Results and Lessons Learned

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Report Submitted: **April 21, 2020**

Abstract

The problem that is being addressed in this technical report is that the client wants a Rube Goldberg device to be built which provides entertainment to the user and performs a simple, but necessary, task. Since people are currently quarantining and not allowed to go to public places, people are craving entertainment in their homes. It is important to create a Rube Golberg machine because while people are in isolation they are going to experience boredom, so this device will make people's times in their homes more enjoyable.

There are some machines that provide a great amount of entertainment for the user; however, I want to make a different design, so that people can have a variety of Rube Goldberg machines to watch. Making more Rube Goldberg machines will allow people to be able to watch more videos, so making more is very useful. The users need a design that is different to others that are already made, so that they have something new to watch. Additionally, they want a Rube Goldberg device that performs a simple task which many do not do. My solution does this by creating a complex chain of events that in the end will squirt hand sanitizer into a person's hand. There are 11 stages and components that will create an entertaining chain of events. My solution is extremely entertaining to watch and also carries out an important task. In the end, the solution that was created provides the user with all that they requested including a virtual stage, completion of an important task and 4 Sparkfun components.

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Problem Statement

The problem is that the client wants a Rube Goldberg device to be built which provides entertainment to the user and performs a simple, but necessary task during this time of quarantine. This is important because while people are in isolation they are going to experience boredom, so this device will make people's times in their homes more enjoyable. Currently available designs provide a lot of entertainment, but many do not perform a necessary task that should be done during this time of isolation.

For the design of the rube Goldberg machine, the client wants a minimum of 3 Sparkfun components included and a minimum of 3 stages to run the chain reaction. Also, there must only be one input to the device meaning that the user can only touch it once and then the rest of the device should be carried out.

Current solutions provide a great amount of entertainment for the user; however, I want to make a different design, so that people can have a variety of Rube Goldberg machines to watch. People are not going to want to watch the same machine over and over again, so people need to continue making these. The users need a design that is different to others that are already made, so that they have something new to watch. Additionally, they want a Rube Goldberg device that performs a simple task which many do not do.

My solution does this by creating a complex chain of events that in the end will squirt hand sanitizer into a person's hand. There are 11 stages and components that will create an entertaining chain of events. Using 4 Sparkfun components and even a virtual stage, the device that was created successfully provides a solution to the problem.

1.2 Stakeholders

One intended stakeholder for the design is Professor O'Connell. He is a client or the design as requested that a device is created that acts as a Rube Goldberg machine. He is not the first person to request this same problem, so there have been many other designs intended for other clients. Another stakeholder which is indirect would be people online who watch the video created from the device. Since the final solution is going online, anyone who watches it will receive some entertainment meaning that the people who view the video are secondary beneficiaries.

1.3 Pertinent topics in engineering

This project was meant to introduce me to the engineering design process in real world applications. It is meant to allow me to show what I have learned in terms of programming and my hardware abilities. This involves the use of Sparkfun and the Arduino software. Together, these allow me to show off what this class has taught me.

Additionally, this problem that I was given was meant to give me an opportunity to create an entertaining and useful product. By creating this real world scenario, I can get a sense of what

future bosses would want from me in careers and how to go about brainstorming for these problems.

This project also allowed me to conduct research on a topic and have experience applying that research into a physical solution. This will be useful in future jobs, so this assignment gives me the chance to understand how to use the engineering design process when creating a solution for a research based issue.

Overall, this has taught me how to use the engineering design process and apply it to real world applications. By letting me use it in a problem solving situation, I can understand the purpose of brainstorming techniques and how to use them in the future.

1.4 Scope

Throughout this technical report, I will go into the background of the problem, the methodology in creating the final design, a full description of the final design including the spending, different components, as well as the results. I will also delve deep into the discussion and analysis of the design, the final conclusion, the recommendations for what I would have changed about the design, and the lessons that I learned throughout this process.

2 Background

Currently there are a massive number of Rube Goldberg machines that exist. The idea of performing some simple task with a complicated series of events interests many people and is a challenge that many engineers enjoy tackling. Rube Goldberg, the man who popularized this phenomenon, was born in 1883 and created a new revolutionary form of art[7]. People found his machines so fun to watch that one was placed in the Museum of Modern Art in New York City[1]. Throughout his life he built many of these fascinating machines and now other people have been creating them as well.

Many competitions have been created where students attempt to build Rube Goldberg machines for a prize[6]. The machines have become so popular that people not only create them to be art, but also to show off their engineering capabilities. Rube Goldberg grew up in San Francisco, California. He got a job in a newspaper company, but quit to follow his passion of being a cartoonist[7]. Unlike many other famous artists, he did not create art on a canvas, but rather built in three dimensions. After following his dreams, he was successful enough to win a Pulitzer Prize[8]. Rube Goldberg changed the way art was seen in the early twentieth century.

Past Rube Goldberg inventions have varied greatly. There have been so many created that making a new machine that is different from every other one is quite difficult. Many have been created that have certain themes around them such as a western setting with cowboy props or ones that have to do with the ocean with a blue color pallet[2]. Additionally, different Rube Goldberg machines have different sources of interest. Some focus on making complex and interesting stages while others value the length more and try to make the most stages[4]. This is something that I will keep in mind when creating my machine and I will have to focus either on length, complexity or a combination of the two. Many people make Rube Goldberg machines that are extremely simple and long so that they do not need a ton of scaffolding or big rooms to make an entertaining show[5]. These decisions all come down to the minds of the engineers.

In order to construct my Rube Goldberg machine, there are certain steps that I need to take. The most important is to make a plan in the beginning before I start constructing. After reading multiple articles, it has become clear that Rube Goldberg machines are extremely difficult to build without following a plan while building[9]. Due to the fact that they are a long series of chain reactions, if one peice of the machine doesn't work then it is a complete failure. Videos have shown that if one stage doesn't work as it was intended to then the rest will not work and it will take a long time to reset every stage that previously went off[3].

Many people who have built Rube Goldberg machines in the past recommend that they are planned out and constructed from the end to the beginning[10]. By setting it up backwards, you keep the main focus on the end goal which is the necessary task and the rest will come as a result. I plan to use this advice when I enter the construction phase of the project and will keep

the past designs that people have made in my mind.

There are not many ethical concerns when building a Rube Goldberg Machine, so this is something that I will not be heavily focusing on. They are generally meant for entertainment, and are usually not at risk of breaking ethical boundaries.

3 Methodology

Defining the Problem

When the client came to me with the problem, I made sure to start by figuring out what the problem was so that I could be sure that I understand the problem. The first question that I made sure I knew how to answer was what I thought the actual issue was. To this, I answered that the problem is that the client wants a Rube Goldberg device that creates an entertaining and enjoyable chain of reactions that in the end carries out a simple, but necessary task.

Additionally, I had to figure out why I cared about the problem. My answer to this is that since we are currently in a time of quarantine where people can not go outside or interact with other people outside of their homes, I feel that it is important that people have fun and entertaining activities to do while in their houses. The activity that will provide something interesting to watch is a video of my Rube Goldberg machine.

Once these questions were answered, an important question came up which asked what the need for a solution was. I answered this by understanding that there are only a limited amount of Rube Goldberg videos on the internet. By creating another video with the machine carrying out an absurd chain of reactions, I can help people to not be bored. If a person had to watch the same videos over and over again, they would become bored, so my video will allow people to have some short lived excitement.

Once these questions were answered and I fully understood what the provided problem was, I was able to write my full problem statement which appears in the introduction section of this technical report.

The methodology section should provide a detailed account of all the methods, assumptions, and procedures undertaken during the work covered by this report, in your case that's your engineering design cycle. This section covers the complete story of your process from when you started working on the problem to when you have completed the analysis of all testing of the prototype.

Solution Generation

In order to come up with ideas for the overall design I decided to go through some brainstorming techniques. First, I did an initial problem analysis and identified what the problem is, where it exists, when it is happening and the extent of the problem as seen in Figure 1. This helped me gauge the scope and allowed me to start coming up with solutions. I also wrote down on a piece of paper every possible item that I could use in the project that I'd be able to find in my house along with possible stages that I think I'd be able to set up which is shown in Figure 2.

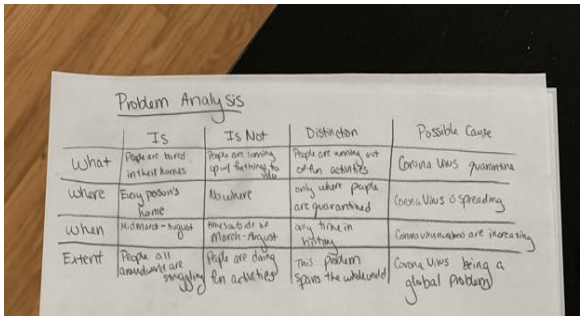

Figure 1 Problem Analysis

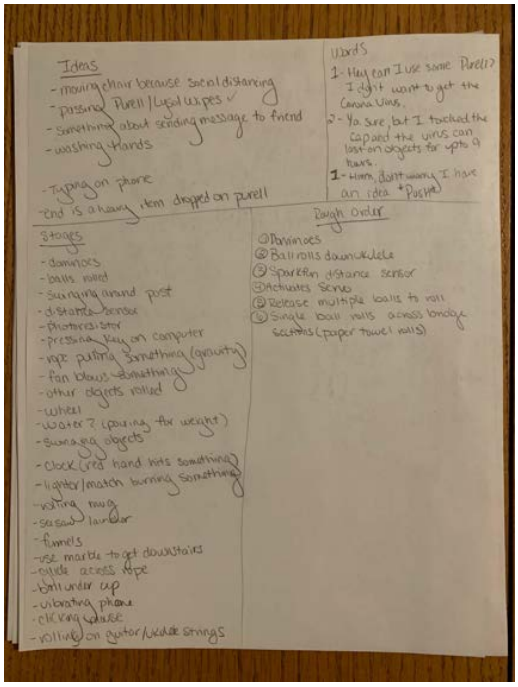

Figure 2 Brainstorming Sheet

Next, I identified my musts and wants for the design to decide what is necessary and what is not as important. Once this was complete I used those goals to create a Go/NoGo chart which outlined possibilities for the different components of the Rube Goldberg device along with how important each of the components are to the overall design. This can be seen in Figure 3.

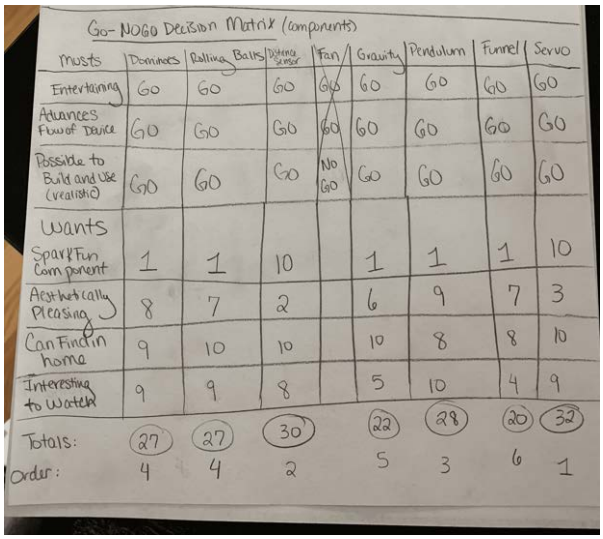

Figure 3 Go/NoGo Chart

Lastly, I created a morphological chart to develop a better understanding of how I will tackle each of my specific goals for the project which is shown in Figure 4. This was a crucial brainstorming session where I was able to come up with many ideas on ways to set up the machine and make it very entertaining to watch.

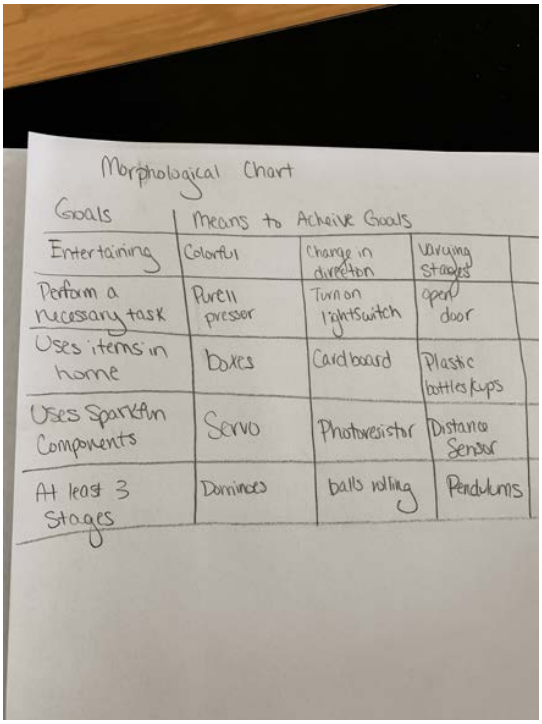

Figure 4 Morphological Chart

Decision

After generating the design ideas for the machine, I had to decide which of the stages and materials I would include in the final design and which I would not use. To do this, I listed out all the possible materials that I was planning on using along with all of the possible stages I was considering implementing. Once this was complete, I began to rule out the ones I can not use. This meant that I crossed out all of the possibilities that were unrealistic. When planning out what I was going to build I needed to make

sure it was possible that I could build it, so I had to be realistic. Anything that would have been impossible to create given my materials and abilities I needed to cross out.

Additionally, I crossed out materials that I could not use because they were not available in my house. Since the budget for this assignment was $0.00 I needed to make sure that everything I planned on using was already accessible in my home. Once this was complete I circled all the materials and stages I felt that I could realistically create and tried to not limit myself too much. Although I wanted to stay realistic I also felt like challenging myself to make a really complex and interesting machine. I let my imagination take over and wrote down stages that I wanted to create using the materials that I decided on using. At this point, I did not take into consideration how they will link together to create a single flowing device. This was focused on later in the design process.

Design Before Implementation

After deciding each of the stages that I planned to use in the final design of the machine, I created a more detailed drawing of what each of them would look like. In Figure 5 a snake shape of dominoes is drawn which establishes where the device will start and what the initial input will be. The materials that are used are listed on the sheet which include dominoes, string and a table.

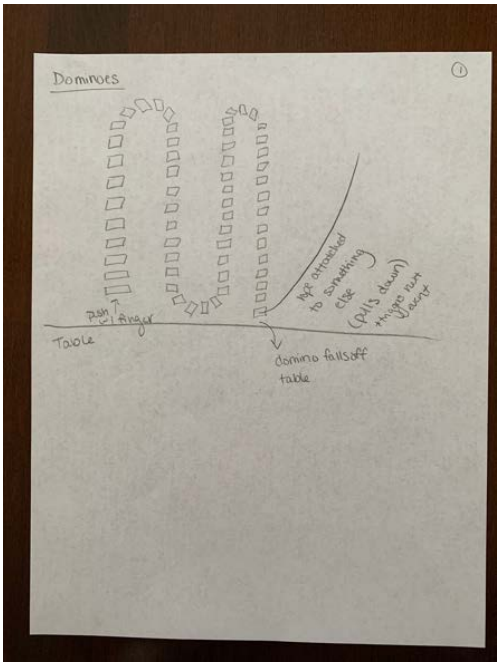

Figure 5 Design Sketch Dominoes

The next detailed drawing that was created is shown in Figure 6. This drawing outlines the stage of the machine that involves a ball rolling and setting off a distance sensor. This was the first of 4 Sparkfun components that will be used in the device.

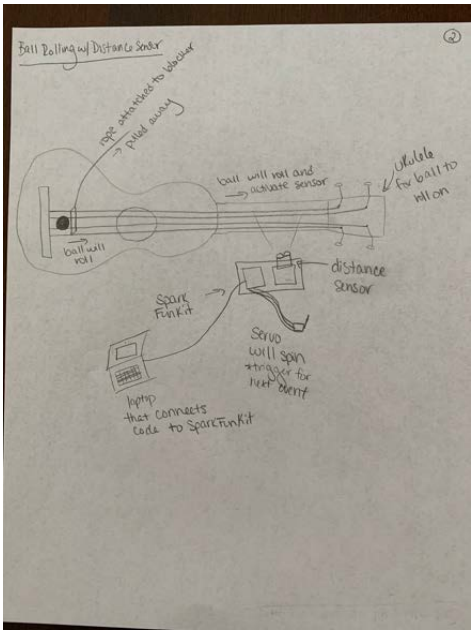

Figure 6 Design Sketch Rolling Ball

After that drawing was created, I drew the stage that involved a servo motor which will turn when the distance sensor is activated. This is shown in Figure 7. This image was drawn to show a servo motor releasing balls that are rolled down a ramp. The balls then trigger a path to fall where balls are rolled through activating the next part of the device.

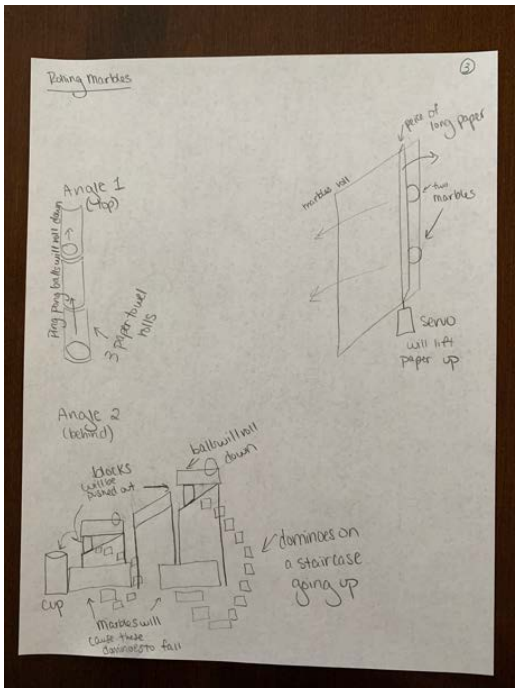

Figure 7 Design Sketch Servo

Following this, I design a stage that involves a seesaw which can be seen in Figure 8. In this drawing, I planned out the next stage of the device which is a seesaw flipping anc pulling a string down which is connected to the ceiling. The string is used to create the next series of events.

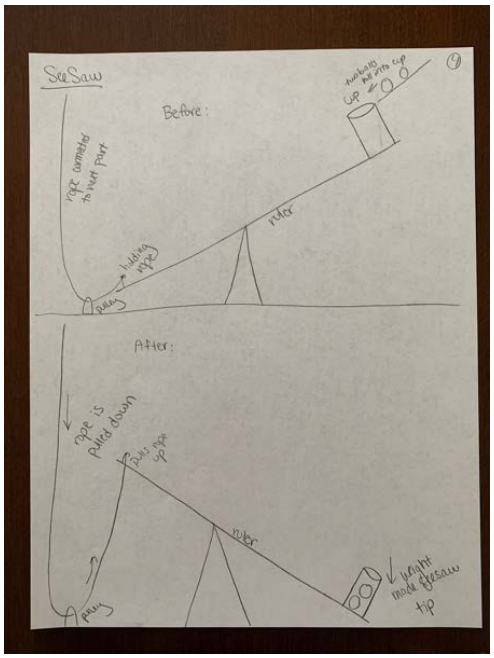

Figure 8 Design Sketch Seesaw

In Figure 9 a drawing is shown that displays what I intended to be the next stage for the device. A ball swings on a string across the room hitting another string that is connected to a wall.

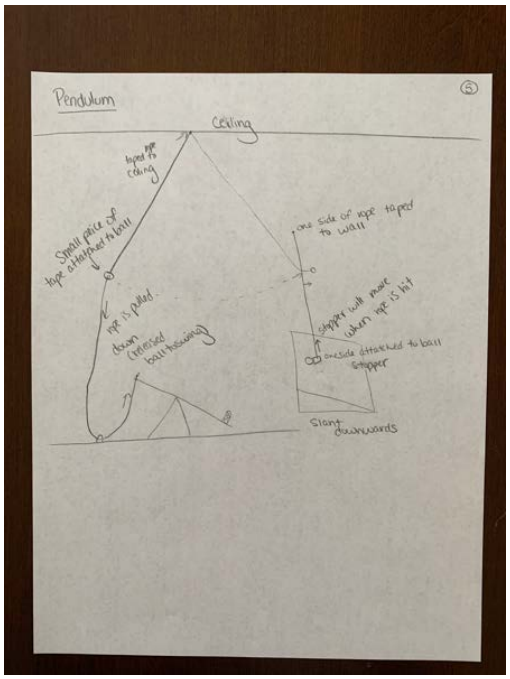

Figure 9 Design Sketch Swinging Ball

After that stage, I drew a series of events where a ball is released in a cup down a ramp where a dark

piece of paper is pushed to cover a photoresistor. This is shown in Figure 10. This was planned so that when the photoresistor is covered the next stage occurs.

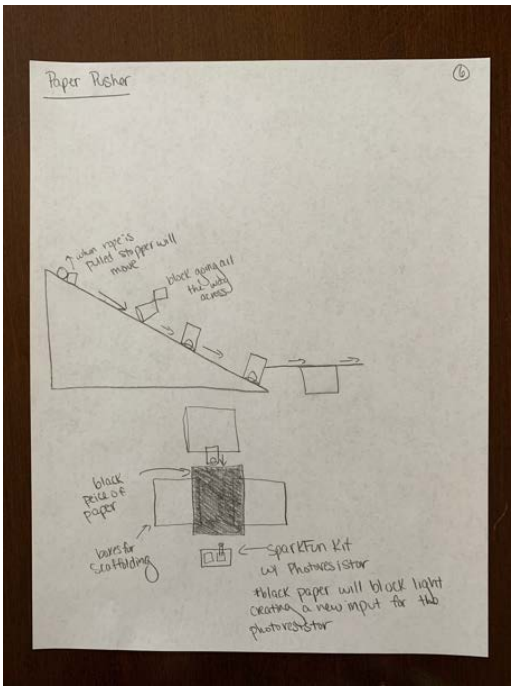

Figure 10 Design Sketch Photoresistor

Lastly, a drawing of the final stage was created which is displayed in Figure 11. In this drawing, a motor spins a wheel to release a rope that is attached to the ceiling. I created this event so that an object can fall on the hand sanitizer bottle allowing some to squirt out. This is the simple, yet necessary task that I planned on completing.

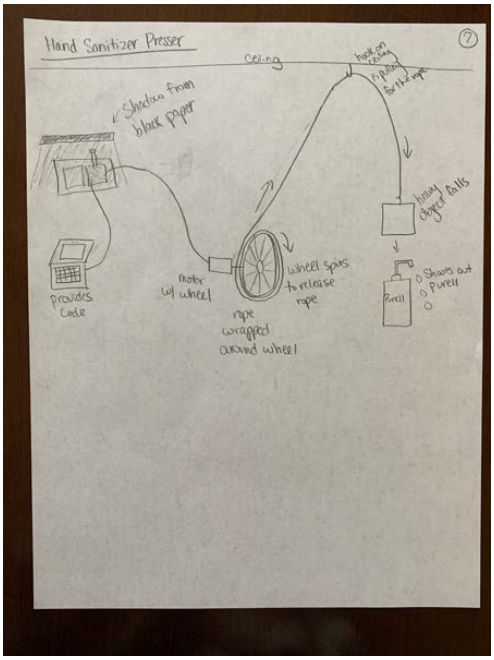

Figure 11 Design Sketch Hand Sanitizer Squirter

After all of the quick drawings were created I used AutoCAD software to draw a large layout of where each of the different stages are going to be located on the table. It serves as a blueprint for where each stage will be. This allowed me to plan for when I was constructing the device. The AutoCAD drawing can be found in Figure 12.

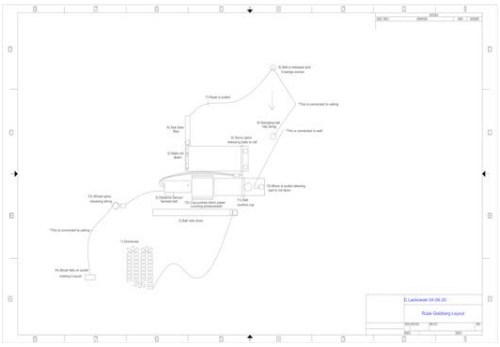

Figure 12 AutoCAD Design Layout

Once I had decided on the materials to use and the stages that I wanted to create, the drawings came easily and I used some of the research I had done on Rube Goldberg machines to create drawings of entertaining and interesting stages.

Implementation

To start the process of implementing my ideas into a fully realized end product, I went around my house and gathered supplies that I was planning on using. When gathering supplies, I realized that there were some objects that I needed to go out and buy from a store, but because of the quarantine I couldn't leave my house. To get around this I used objects that were similar to the ones I wanted. For example, instead of using actual dominoes, I used square board game pieces that were able to stand up and knock each other over in a similar way. I made sure to gather all of the actual materials that would be used in the stages along with the construction materials such as tape, string and glue.

When everything that I needed was gathered on the table that I planned on making the machine on I started to construct the machine. In order to do this in a systematic way, I built it from the back towards the front. When doing my research on how to build machines like these I read that it is easiest to do it in this order. So, I created each of the 11 stages using the materials and left them separate from each other. I did not want to make them interact until they were all finished being made separately.

When each stage was constructed on their own, I had to combine them together. In order to do this, I mixed this stage of implementation with the testing stage. I sort of tested as I was putting them together. For a project like this it does not make sense to make the entire thing and then test it because if one piece does not work then the entire thing won't work. So, I put two stages together and then tested. This way I made sure that I would not have to remake every stage when I am in the testing stage.

Testing

In order to properly test the device that was created, I made sure to go stage by stage and focus directly on each aspect of the product. Once each of the stages were constructed at a simple level, I took each on and made sure it was successful. If a stage did not work as intended or was not carried out to completion I made sure to go back and fix some of the parts that were incorrect. For example, when the dominoes did not make it to the end of the line, I had to add some so that each domino would hit the next. Also, I had a mishap where I used a different size ball when testing a stage then when I was constructing it which made me have to readjust the weights. This occurred during the seesaw stage.

Once each stage was working independently, I tested the stages with the one that came after to ensure that the chain of reactions would occur. It would be impossible to know if the final design was going to work if I had not tested each pair of stages. This meant that I wasn't checking the inner workings of each stage, but rather the way that they were going to interact. During the testing phase I had to change the length of some ropes and weights of pieces so that the stages would be able to continue the flow of the device.

4 Final Design

The final design for the device is a complex series of events that ends in a hand sanitizer bottle being squirted. There are many stages and unique components.

In Figure 13 the first stage is shown. Here, there dominoes lined up in a curved pattern which will knock over one by one. This is where the device starts and in order to use it, the user must press the first domino forwards. When the last domino falls off the table a string that is attached to it will cause another domino to fall activating the next stage.

Figure 13 Dominoes stage

The next component of the device is a distance sensor. In figure 14 the next stage is shown. A ball will be released on the strings of a ukulele causing the distance sensor to sense it. This will send information to the red board allowing the next stage to be carried out. This is where the first Sparkfun component is being used.

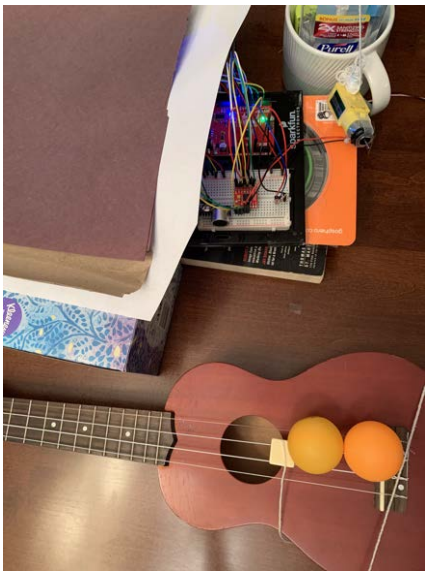

Figure 14 Rolling Balls Stage

Once the sensor sees the ball rolling across, it will trigger a servo which is the second Sparkfun component. The servo will pull strings causing balls to roll down a slant which in turn causes more balls to roll across. This stage can be seen in Figure 15. the balls that roll will cause the following stage to be set up.

Figure 15 Servo Stage

Following this, the balls will roll into a cup which is connected to a seesaw. This can be seen in Figure 16. Here, the weight of the balls will cause the see saw to tip which will move cause the pen attached to press the call button on a touchscreen phone. This activates the next section of the device.

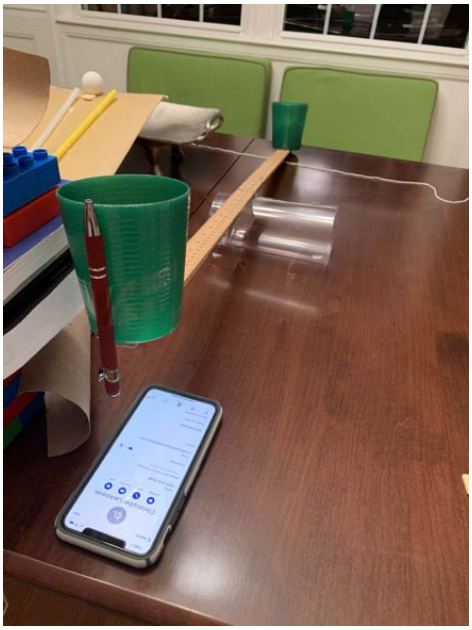

Figure 16 Seesaw Stage

In Figure 17 the next stage is shown where a phone falls off a bin which pulls a string allowing a ball to swing across the room. Using two phones I was able to create a completely virtual component where two different electronics were used to continue the flow of the device. When the phone falls, a string is pulled which releases the ball to swing.

Figure 17 Swinging Ball Stage

After that stage, the ball on the string hits another string which pulls and releases a cup to slide down a ramp. This cup pushes a balck piece of paper on top of a photoresistor which activates the next section of the device. This stage uses the third Sparkfun component. This is shown in Figure 18.

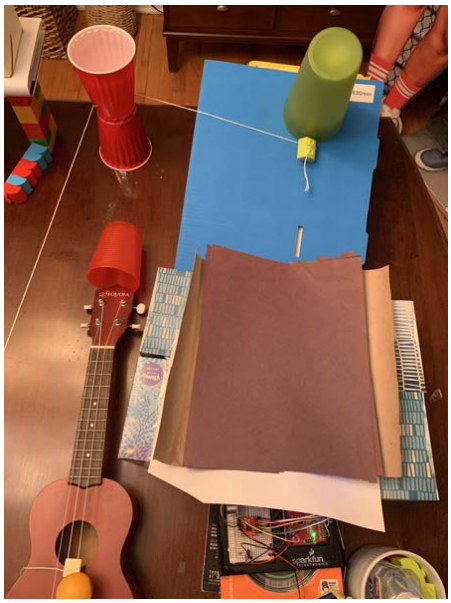

Figure 18 Photoresistor Stage

Lastly, the shadow over the photoresistor causes a motor to spin which coils rope and pulls down on the top of a hand sanitizer bottle. This can be seen in Figure 19. This is the last section and makes the device carry out the simple, yet necessary action of squirting Purell onto the user's hand.

Figure 19 Hand Sanitizer Squirter Stage

This final product costed me a total of $0.00. All of the materials described were found in my home and none were bought at a store or purchased online. As seen in Table 1, every component used was free. A large scale view of the entire device and all the different stages next to each other can be seen in Figure 20.

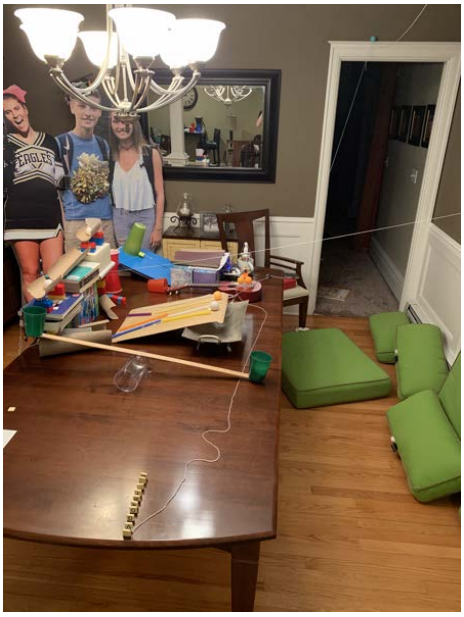

Figure 20 Large View of Final Machine

Item	Unit Value	Units	Qty	Value	Cost	Source
Boxes	$0.00	ea	10	$0.00	$0.00	My house
Ping pong balls	$0.40	ea	12	$4.80	$0.00	My house
Cup	$0.49	ea	1	$0.49	$0.00	My house
Dominoes	$0.20	ea	100	$20.00	$0.00	My house
String	$16.00	rolls	1	$16.00	$0.00	My house
Paper Towel Rolls	$0.00	ea	6	$0.00	$0.00	My house
Tape	$1.99	rolls	1	$1.99	$0.00	My house
SparkFun Components	$79.99	ea	1	$79.99	$0.00	My house
Computer	$1,000.00	ea	1	$1,000.00	$0.00	My house
Lego Blocks	$1.00	ea	30	$30.00	$0.00	My house
			Total:	$1,153.27	$0.00	

Table 1 Final Budget of the Device

5 Results

Since the success of my solution is based on subjective opinions, there are no quantifiable results that come from the solution. The product was also not tested by the user which creates a lack of results.

Success for this project needs to be looked at differently than other projects. Due to the fact that an important criteria for the solution was that it was entertaining, that is what my product can be judged off of. When the video of the product is online it can be judged based on comments from viewers. In my opinion, it was relatively entertaining to watch, but I need more data to be able to decide whether it was objectively entertaining.

Some identifiable results that can be discussed are whether or not I gave the client what they wanted and met the standards that they asked for. The device that I made used a total of 4 Sparkfun components and had 11 stages. Also, it carried out a simple, yet necessary task of squirting a hand sanitizer bottle into the hand of a user.

While results are hard to quantify for a solution like this, there are ways to understand the results of the project. It is up to the user to decide on whether I created a product that succeeded in providing what they asked for.

Although this machine was able to work once for the final video, that was the only time it worked completely. This machine was not very reliable since it took over 20 trials to get every component of the machine to work together nonstop. This involved setting it up again and again multiple times every time it did not run to completion. This included making minor tweaks and fixes every time, but this is not displayed in the final video. Overall, the machine was accurate for the one time that it was successful, but in terms of reliability it would need to have major changes before it was consistent enough to work multiple times in a row. The link to the video of the machine working once can be found in Figure 21.

https://www.youtube.com/watch?v=VaI0rGVCkWs

Youtube Link to Video of Working Machine

6 Discussion/Analysis

The results from the testing of the device show that the solution that was created was successful. The device that was created involved the use of 4 separate Sparkfun components which shows my understanding of the constraints and requirements from the client. Additionally, the machine involved a total of 11 different stages. This shows that I wanted to give the client an interesting entertaining product and went above and beyond to give them more than what they required.

The device only uses one input for every stage to be carried out. This input is the user pushing the first domino in the first stage and from that point onwards the rest of the stages function automatically in a linear chain of events. This was a majorly important requirement from the client since it is the main request that they asked for. When creating a Rube Goldberg machine, the user should only provide one input which means touching the machine one time. I was able to do this which shows my understanding of what the client wanted and was asking for. Had this requirement not been met, the entire device would have been unsuccessful and I would have not given the user what they wanted.

A strength of this design is that the number of stages is so high. As I stated earlier there are 11 unique stages in the machine which is much greater than what was asked for. Although some clients may not want more than they asked for, this client made sure to specify that they wanted a minimum of 3 stages, so anything about 3 is allowed. This would be a major strength since it makes the design unique and exciting.

One weakness of the design would be the location of the different stages. Although the stages are unique and entertaining, their placement on the table is not very neat. From an objective point of view, the layout is quite chaotic and could definitely be improved on in the future. The complexity of the stages made it so that it could only be built in a certain way which made it very messy. From a viewer's eye it is reasonable to say that a major weakness is the aesthetic aspect of the machine.

7 Conclusion

The device that was created to provide a solution to the client's problem met or surpassed all the technical requirements listed in the introduction. The final design involves the use of a minimum of 3 Sparkfun components, a minimum of 3 separate and unique stages and also carries out a simple, yet necessary task which in my device is squirting a hand sanitizer bottle. This was also all done with only one input and no other human interactions other than the initial starting action. The device was able to meet all these goals although it lacked aesthetic appeal.

My Rube Goldberg machine that I created had made use of 4 Sparkfun components. These included a distance sensor, servo motor, photoresistor and motor. These worked together to create the seamlessly flowing machine. Also, there were 11different and unique stages total. These involved rolling pieces, items swinging from the ceiling, objects falling and much more. These stages all worked together to create one chain of events that was quite entertaining to watch. It used different directions and motions to make a unique design for a Rube Goldberg machine.

In the end of the chain reaction, a hand sanitizer bottle was able to be squirted. This can be seen as a necessary, yet important task based on the current times. Since there is currently a spread of COVID-19 and germs are getting into everyone's homes, the machine is able to encourage the practice of good hygiene in homes by doing it in a fun and entertaining way. Although squirting a bottle of Purell is not an action that would normally be so important, creating designs that are necessary during the current times is a great thing to do. The action of using the hand sanitizer can be viewed as necessary and simple solely based on what is currently happening all around the world.

Overall, a final product was created that met all of the requirements laid out by the client. Although there are some changes that could be made to make it more aesthetically pleasing, the overwhelming number of stages and Sparkfun components show that the final design turned out to be a viable solution that the client can use.

8 Recommendations

There are a large amount of recommendations that I would give if I had more time to work on the solution. One of the major pieces of advice would be to use better materials. A lot of the materials that were used in the final product were not very stable and required the use of tape and adhesive. This means that it is not commercially ready and cannot be mass-produced. If there was more time moving forward, I would put my energy into replacing books with stable boxes, yarn with a sturdy rope, straws with metal bars and the large envelopes that were used with large sheets of plastic. This would improve the product greatly and make it easier to create.

Another recommendation that I have for anyone continuing to work on the machine is to space the stages out more. The final design is very compact and only takes up about 60 square feet of space. If the stages were more spread out on a large table, the final product would look more satisfying and visually appealing. Generally, a person watching Rube Goldberg machines work would want the stages to flow in a linear pattern. My solution runs back and forth across the table which is a little all over the place.

If I were to go back to the beginning and restart on the machine, I think it would have been very helpful to do more research on the topic of Rube Goldberg machines. They are very complex machines with interesting backgrounds and the information received from the research would have made the construction process much easier. Although I did a large amount of research from the beginning, learning about strategies for construction would have benefitted me when I was starting my design process.

Rube Goldberg machines are very interesting devices to watch. Viewers of these devices tend to find those that are longer to be more interesting and entertaining to watch. Had there been more time provided to me, I would have made many more stages to increase the visual appeal. Having more stages would make the final product much more interesting, so any worker who continues this project should attempt to make it longer. Rube Goldberg machines are meant to be absurd and take long routes to get to the final task, so making the device longer will make it m

9 Lessons Learned

9.1.1 Resources

Although there was not an official budget that I needed to stay under, I can say that I was successful when it comes to the resources I used. I made sure to find every material that I would need in my house which kept the amount that I spent at $0.00. This was a major success for this project however in future projects using household items will not be doable. Due to the circumstances of the project, I was unable to go out and purchase items, but this will not always be the case.

I devoted a few weeks to this project. I definitely learned some lessons about time management because I left the construction until the last few days which was not a great idea in hindsight. I feel as though this is because of the fact that I was not able to get help from FYELIC or any of Northeastern University's on campus resources in a face to face manner. In the future I plan to take timing into consideration and follow the schedules that are outlined in my Gantt Charts.

9.1.2 Reflections on Learning

Overall, this project has allowed me to learn a lot about the basics of engineering and understand the design process completely. When the project was assigned I was relatively stuck on how I would go about building a Rube Goldberg Machine. It seemed like an overwhelming task that I would not be able to achieve. However, through the brainstorming methods that I was taught and the breakdown of every aspect of the project, it became easier than what I had originally anticipated. The project allowed me to realize that breaking down problems into smaller individual parts to focus on will make difficult tasks more manageable.

Most aspects of this assignment were relatively new to me. I haven't had much experience with creating solutions to real world problems and then actually carrying out that solution to make a real prototype. This entire assignment was something that I have not done before. Despite this, I was able to come up with a working solution that accomplished the main goal I initially set out to achieve. Throughout the design process, I had to teach myself to slow down and really take the time to weigh out all the options. I could have gone with completely different stages or interpreted the problem in a completely different way, but using the brainstorming strategies I came up with a solution that I take pride in. This has shown me that patience in engineering is important along with not rushing into anything because it seems like an easy solution. This whole process has taught me a lot and gave me the mindset of being a real engineer.

This knowledge will definitely help me in my careers both during my coops and my jobs later in life. This project gave me the basic knowledge of how engineers go about solving problems and tackling situations that are given to them. These are skills that are going to be crucial if I want to keep up with the fast paced style of real working environments. There are not many second

chances when working for a real company, so this assignment allowed me to figure out how to work through problems and get it right the first time. I have learned alot from the project and will use this project as a stepping stone to being a successful worker in my future career.

9.1.3 Reflections on Your Engineering Design Process

I would say my engineering design process has evolved to become quite successful. I tend to start by using some brainstorming techniques that were taught to me and then using some free thinking to create a realised solution. I usually work best in environments where I am able to consult with others and work in groups. This project proved to be more difficult due to the fact that I had to work alone. Had I been with a partner or a group I would have most likely been able to come up with a more creative solution.

This project made me realize that problem solving in engineering is quite fun. Although I have always enjoyed making things and doing engineering tasks, this assignment ensured me that I am in the right field. This process has been quite enlightening for me and has allowed me to understand more about myself.

I need to work on how I start my design process. I tend to jump right into the project and want to be hands on right away. However, this is not always beneficial. For this project I had to put the physical aspect away in the beginning stages and focus on drawing and brainstorming. This allowed me to have a complex and entertaining final product that I am very proud of. My engineering design process has been successful for me so far and it will continue to evolve as I work on different types of projects in the future.

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Appendices

Appendix A – EDP Analysis

Figure 1 Problem Analysis

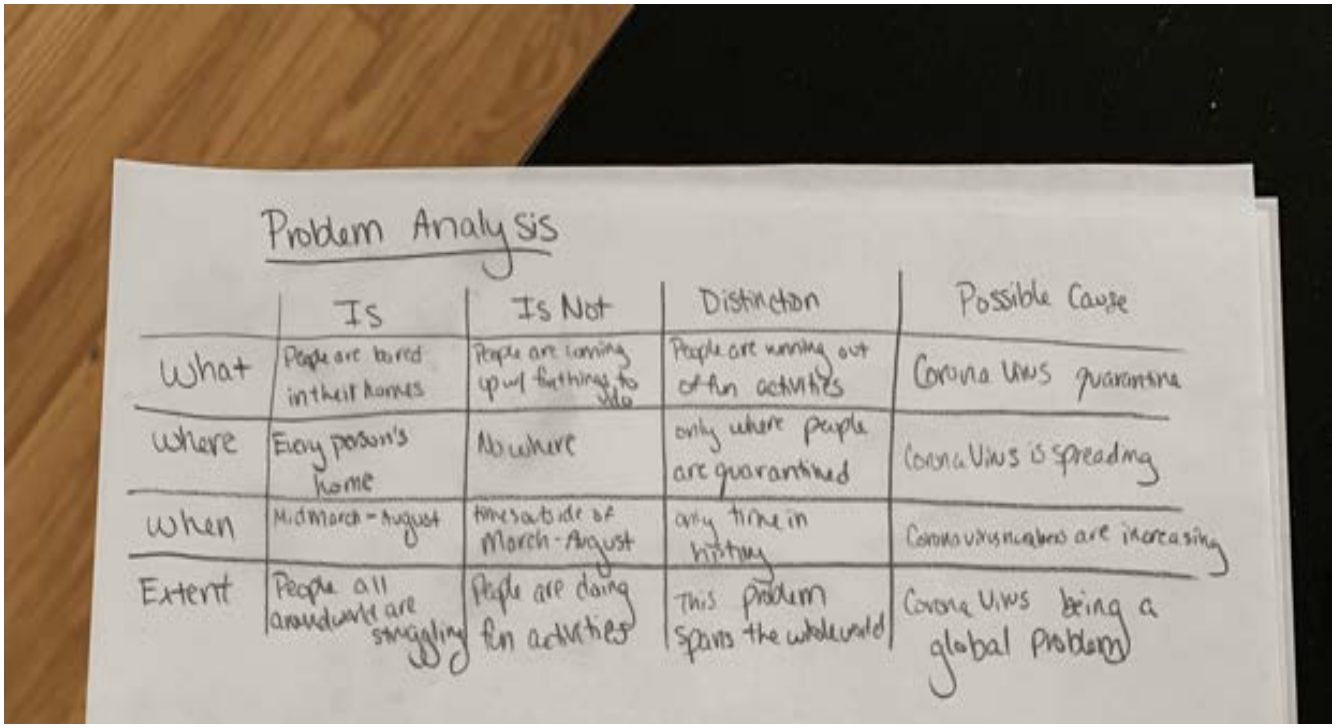


Figure 2 Brainstorming Sheet

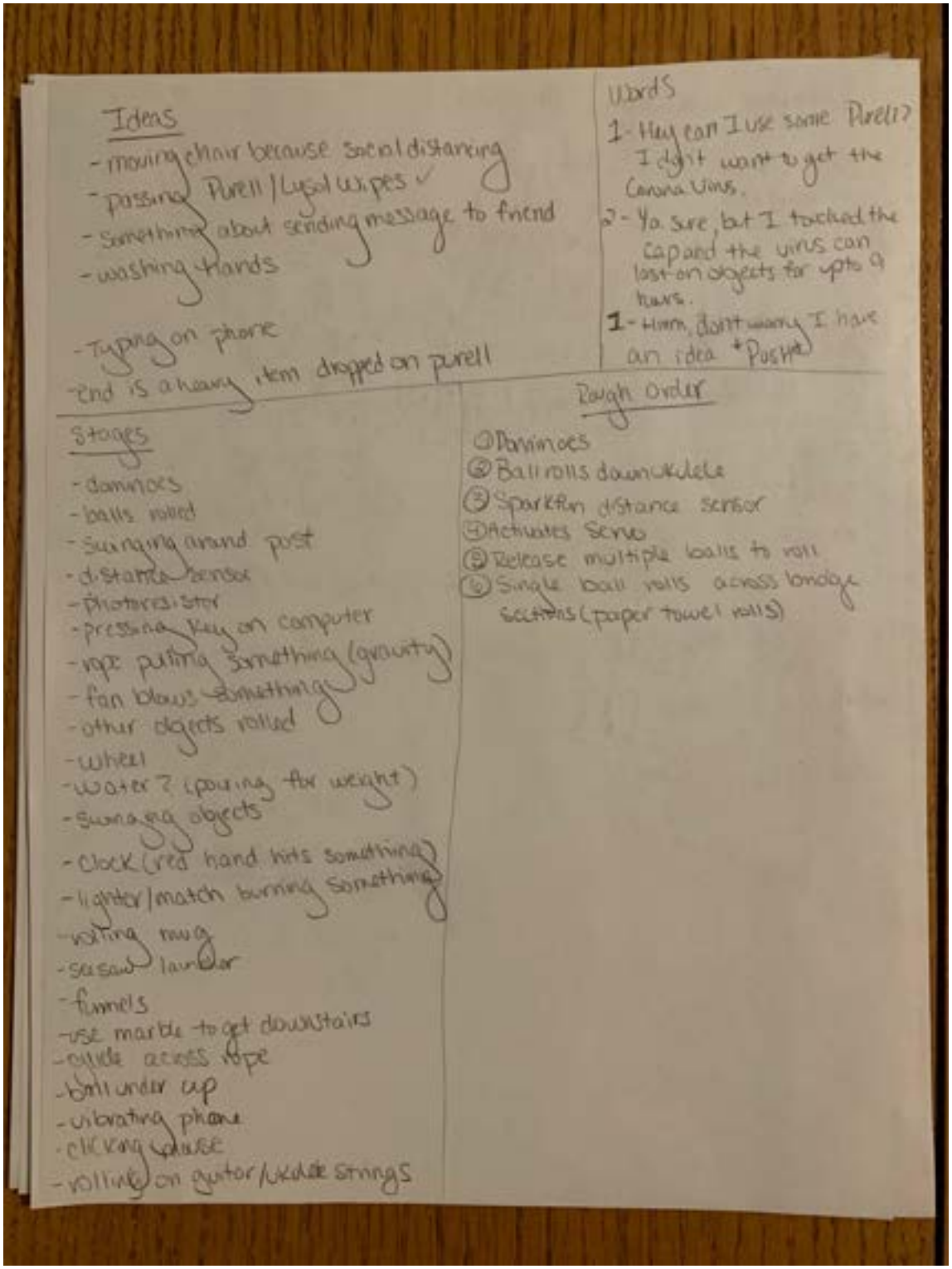
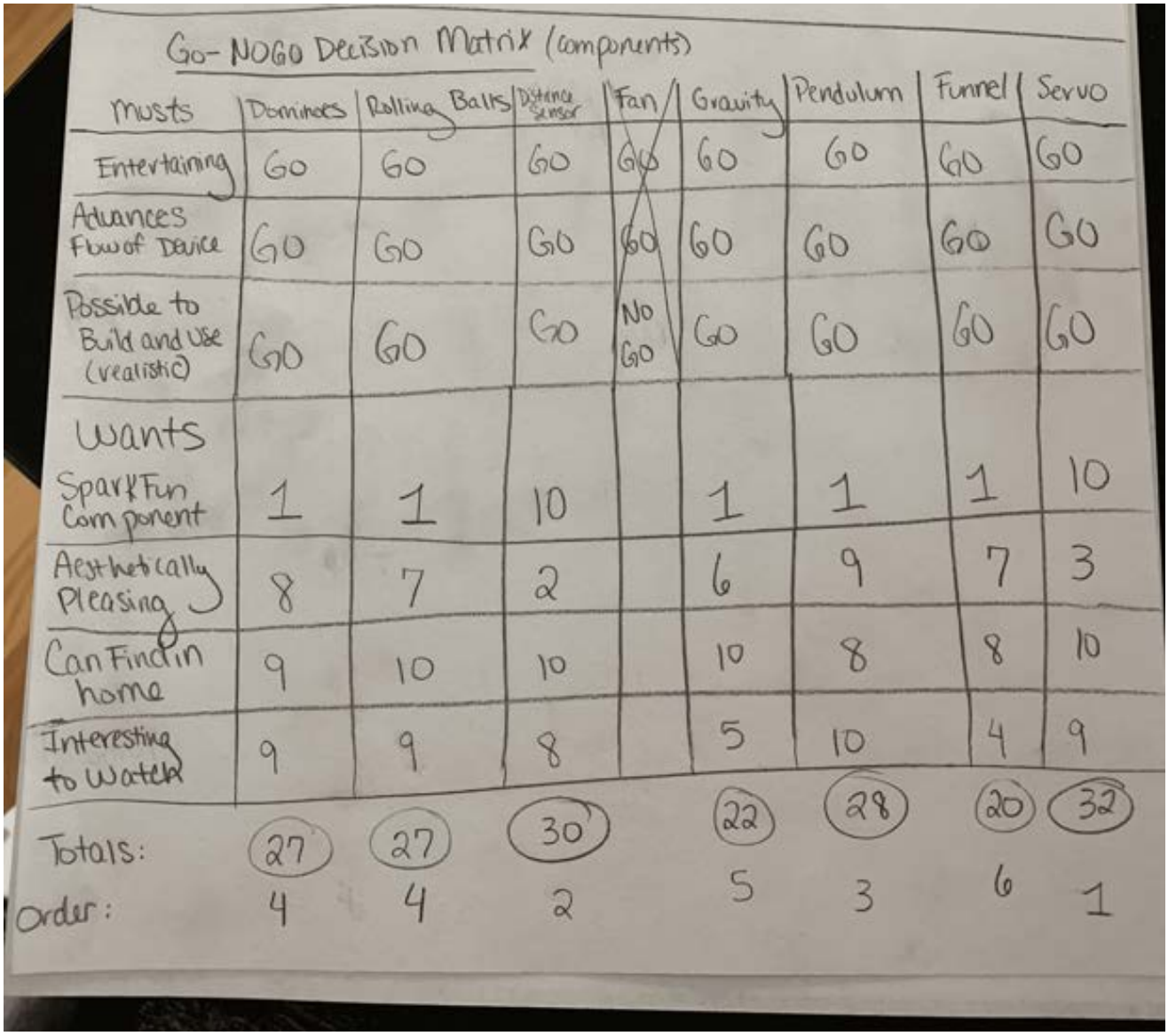


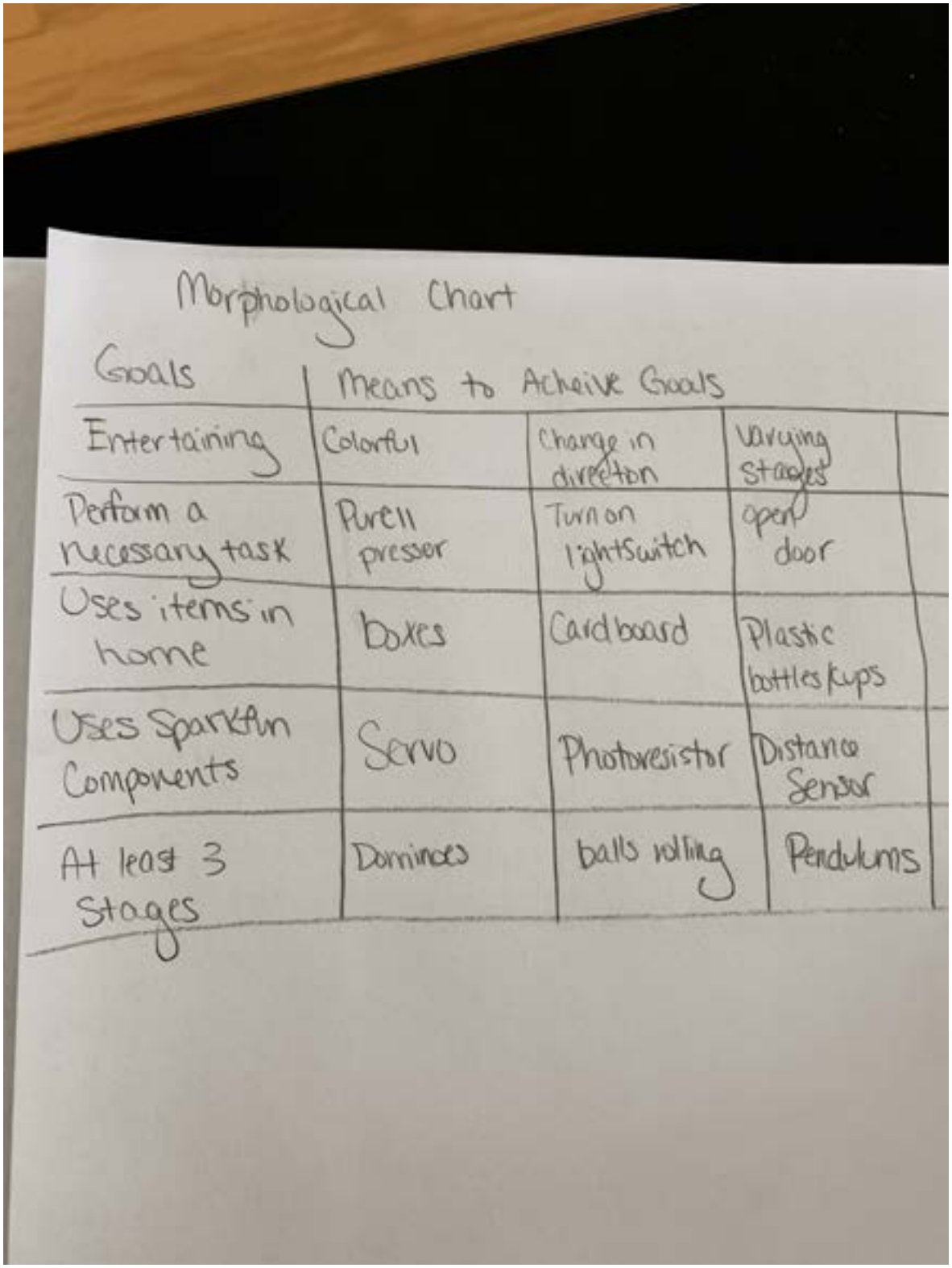
Figure 3 Go/NoGo Chart



Go-NOGO Decision Matrix (components)

musts	Dominoes	Rolling Balls	Distance Sensor	Fan	Gravity	Pendulum	Funnel	Servo
Entertaining	GO	GO	GO	~~GO~~	GO	GO	GO	GO
Advances Flow of Device	GO	GO	GO	~~GO~~	GO	GO	GO	GO
Possible to Build and Use (realistic)	GO	GO	GO	NO GO	GO	GO	GO	GO
wants								
Spark Fun Component	1	1	10		1	1	1	10
Aesthetically Pleasing	8	7	2		6	9	7	3
Can Find in home	9	10	10		10	8	8	10
Interesting to Watch	9	9	8		5	10	4	9
Totals:	(27)	(27)	(30)		(22)	(28)	(20)	(32)
Order:	4	4	2		5	3	6	1

Figure 4 Morphological Chart



Morphological Chart

Goals	Means to Achieve Goals			
Entertaining	Colorful	Change in direction	Varying stages	
Perform a necessary task	Purell presser	Turn on lightswitch	open door	
Uses items in home	boxes	Cardboard	Plastic bottles/cups	
Uses SparkFun Components	Servo	Photoresistor	Distance Sensor	
At least 3 Stages	Dominoes	balls rolling	Pendulums	

Appendix B – Any detail drawings

Figure 5 Design Sketch Dominoes

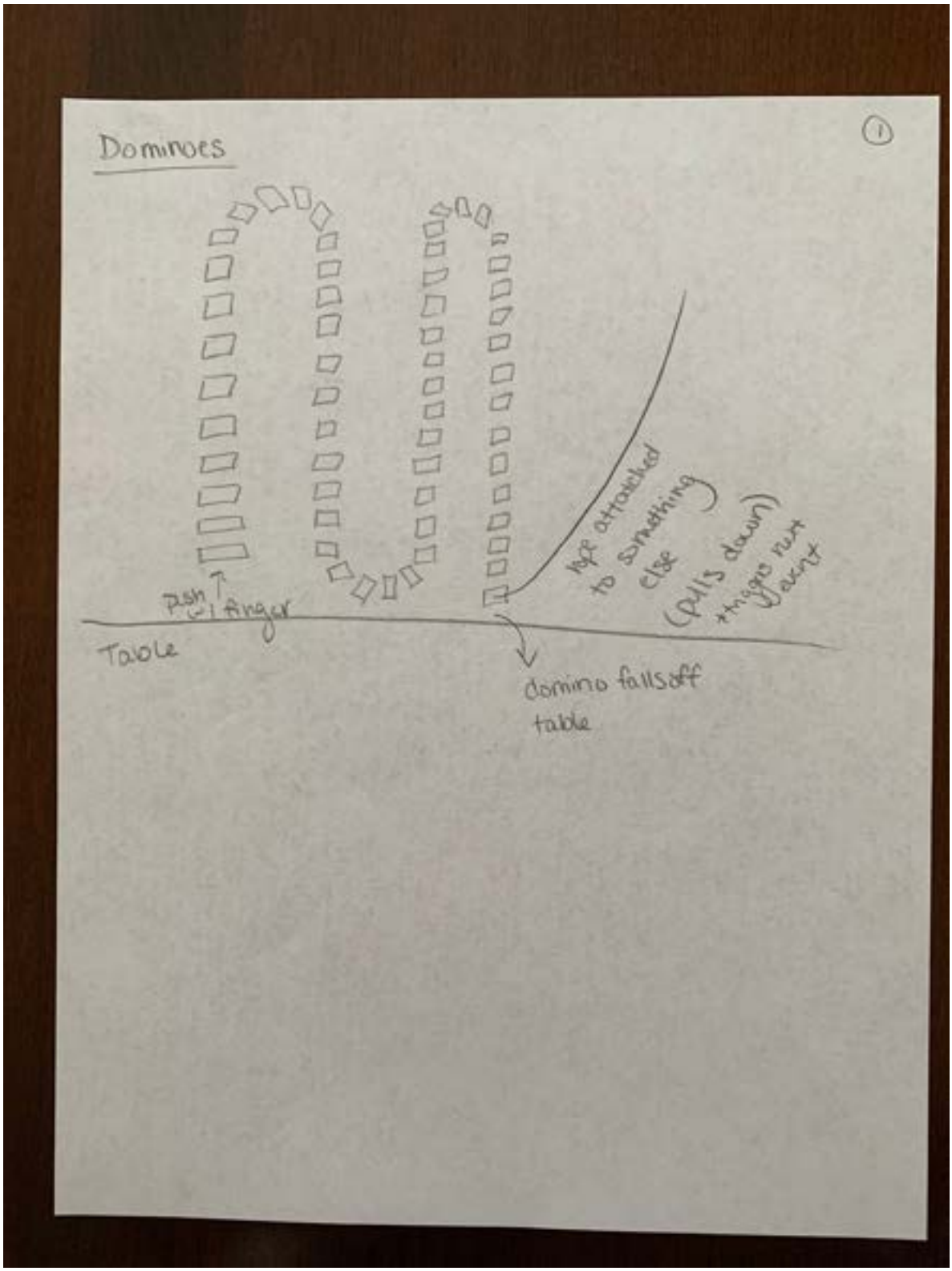


Figure 6 Design Sketch Rolling Ball

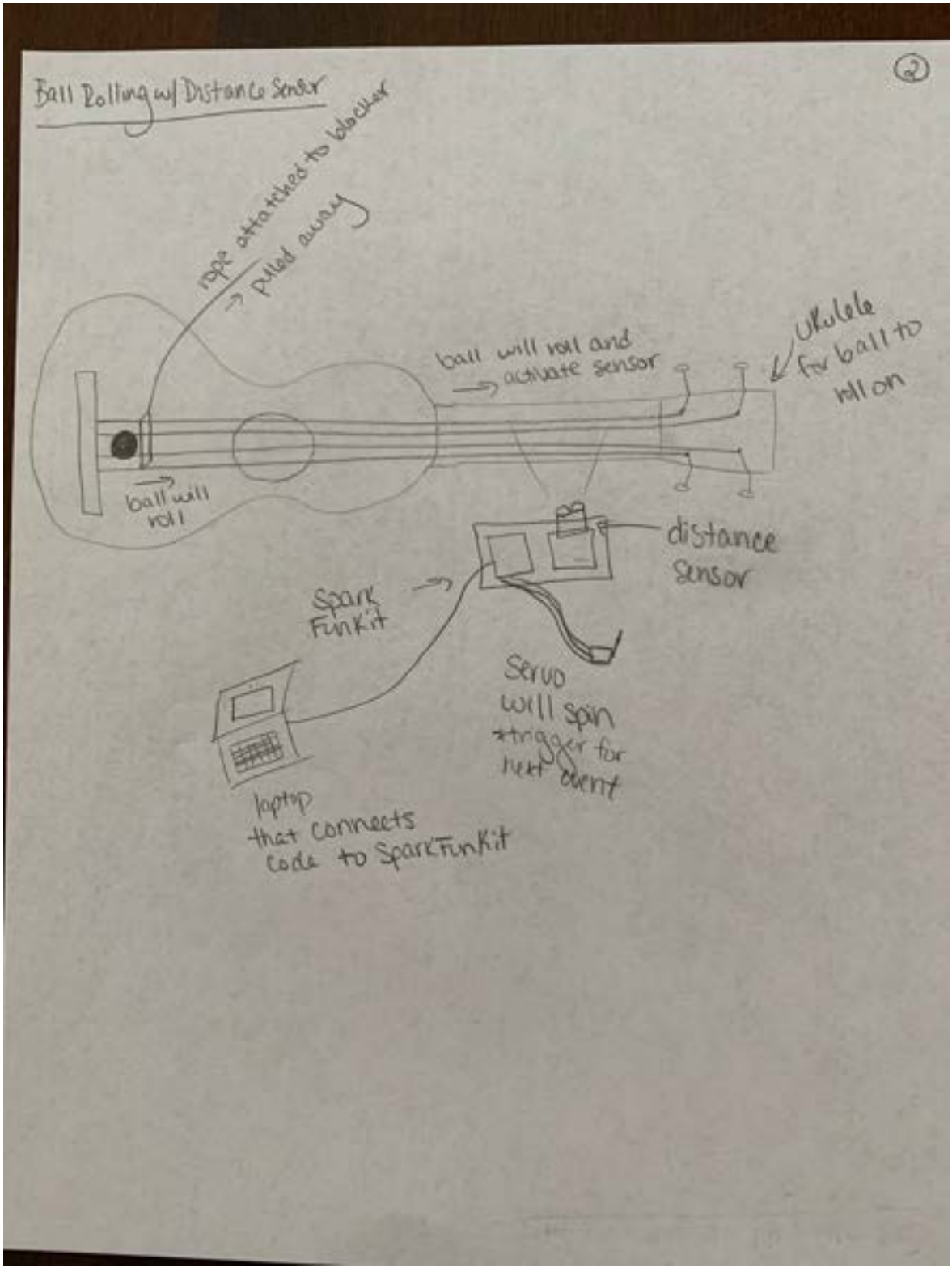


Figure 7 Design Sketch Servo

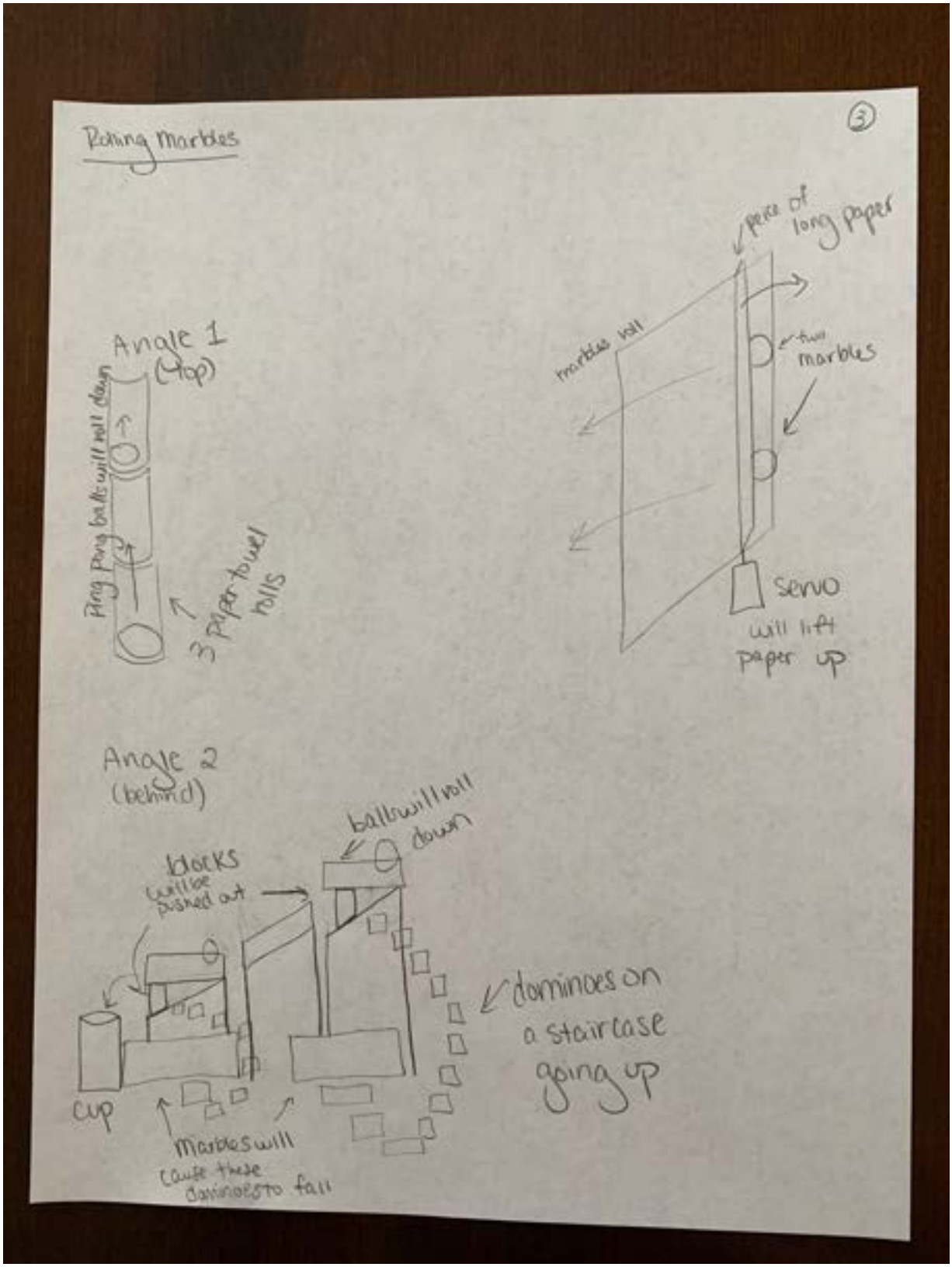


Figure 8 Design Sketch Seesaw

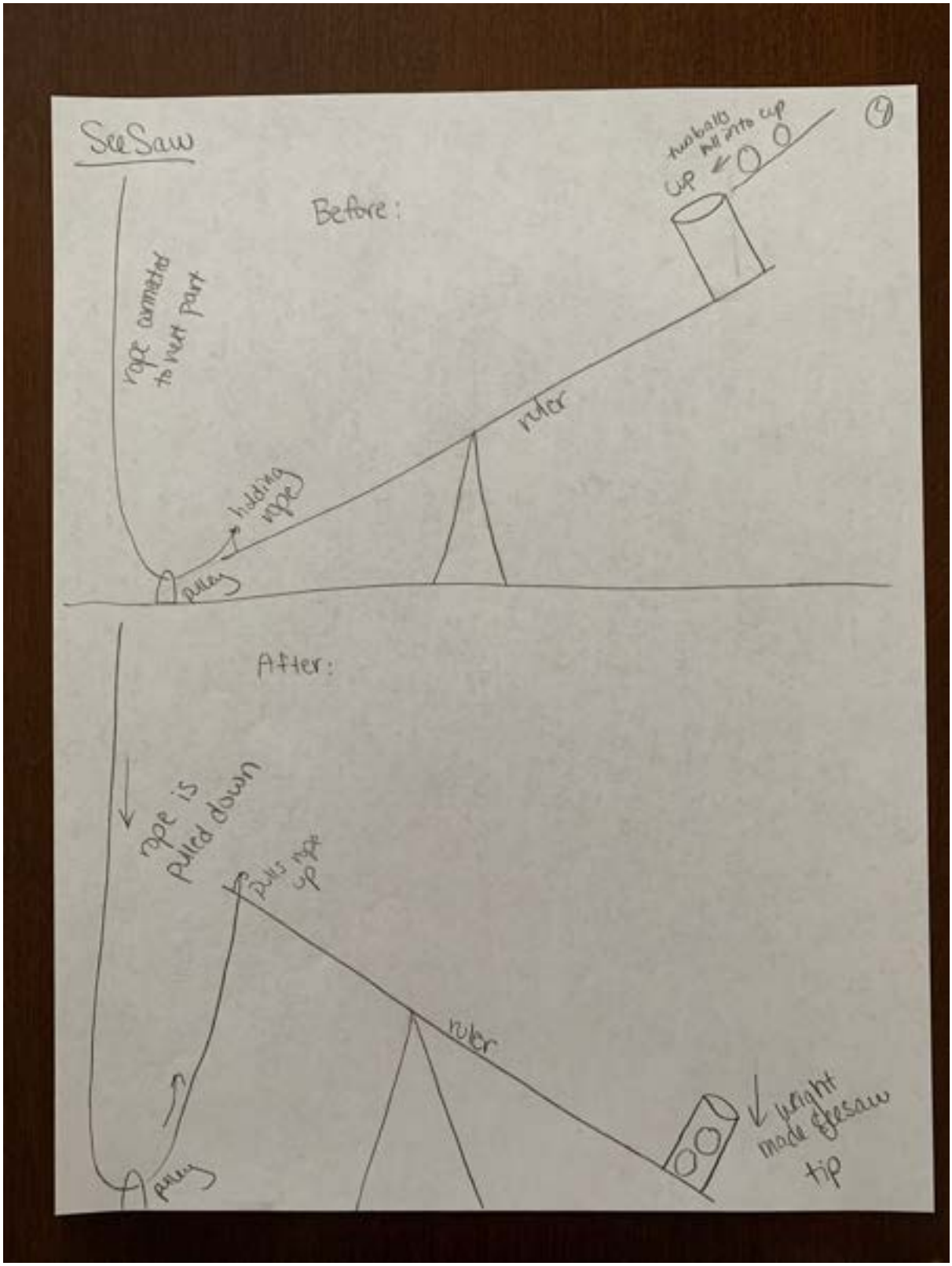


Figure 9 Design Sketch Swinging Ball

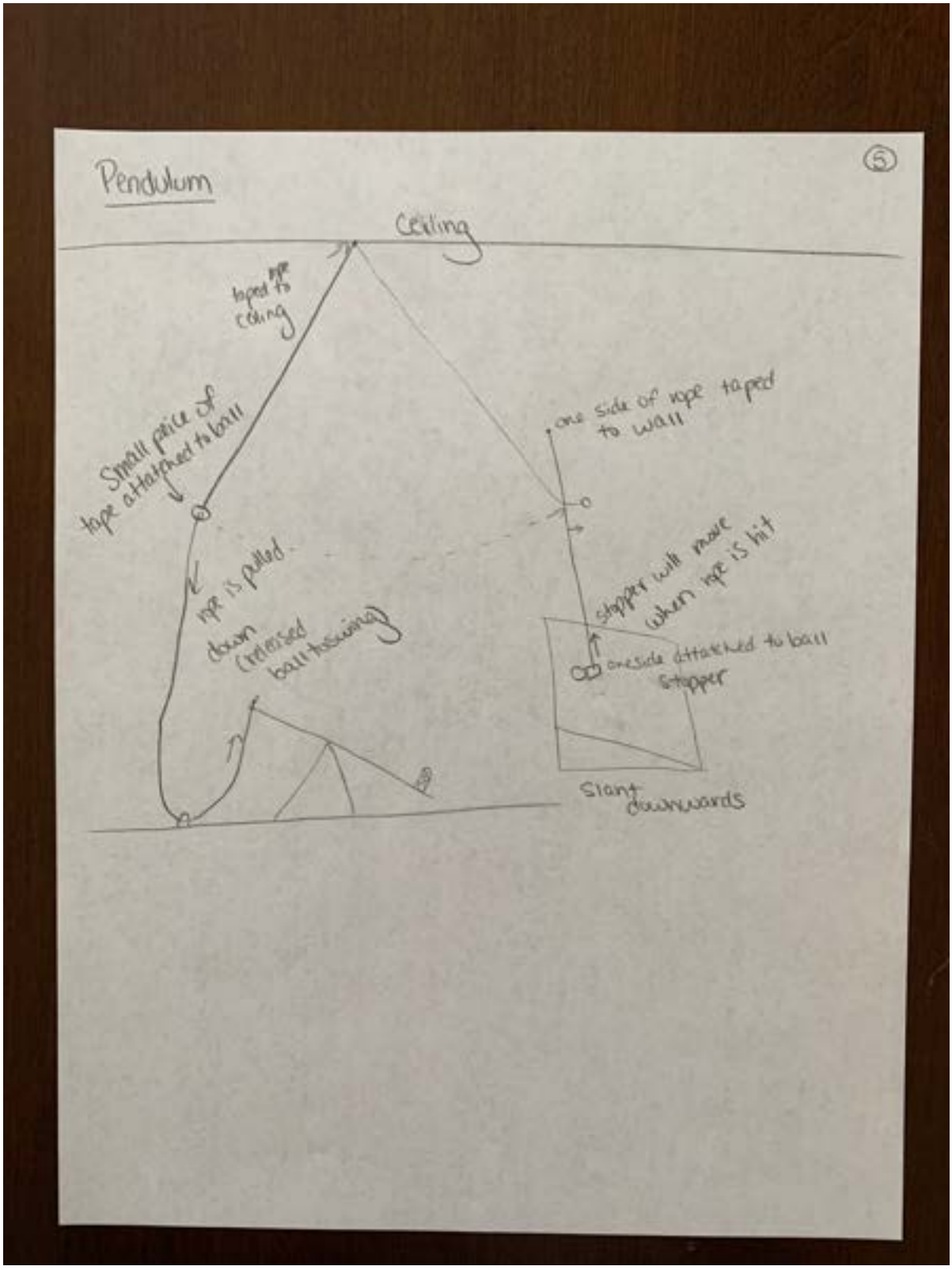


Figure 10 Design Sketch Photoresistor Cover

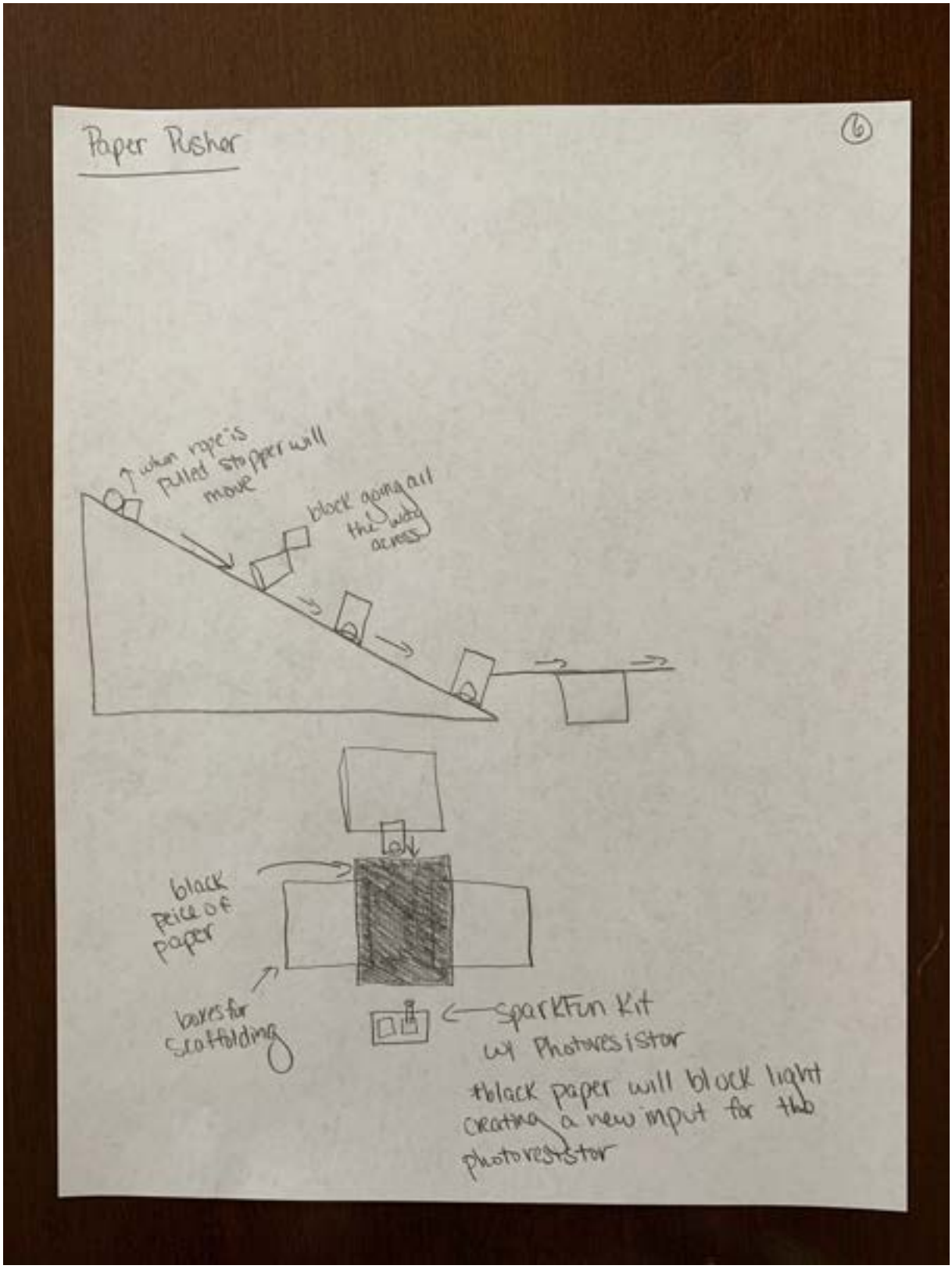


Figure 11 Design Sketch Hand Sanitizer Squirter

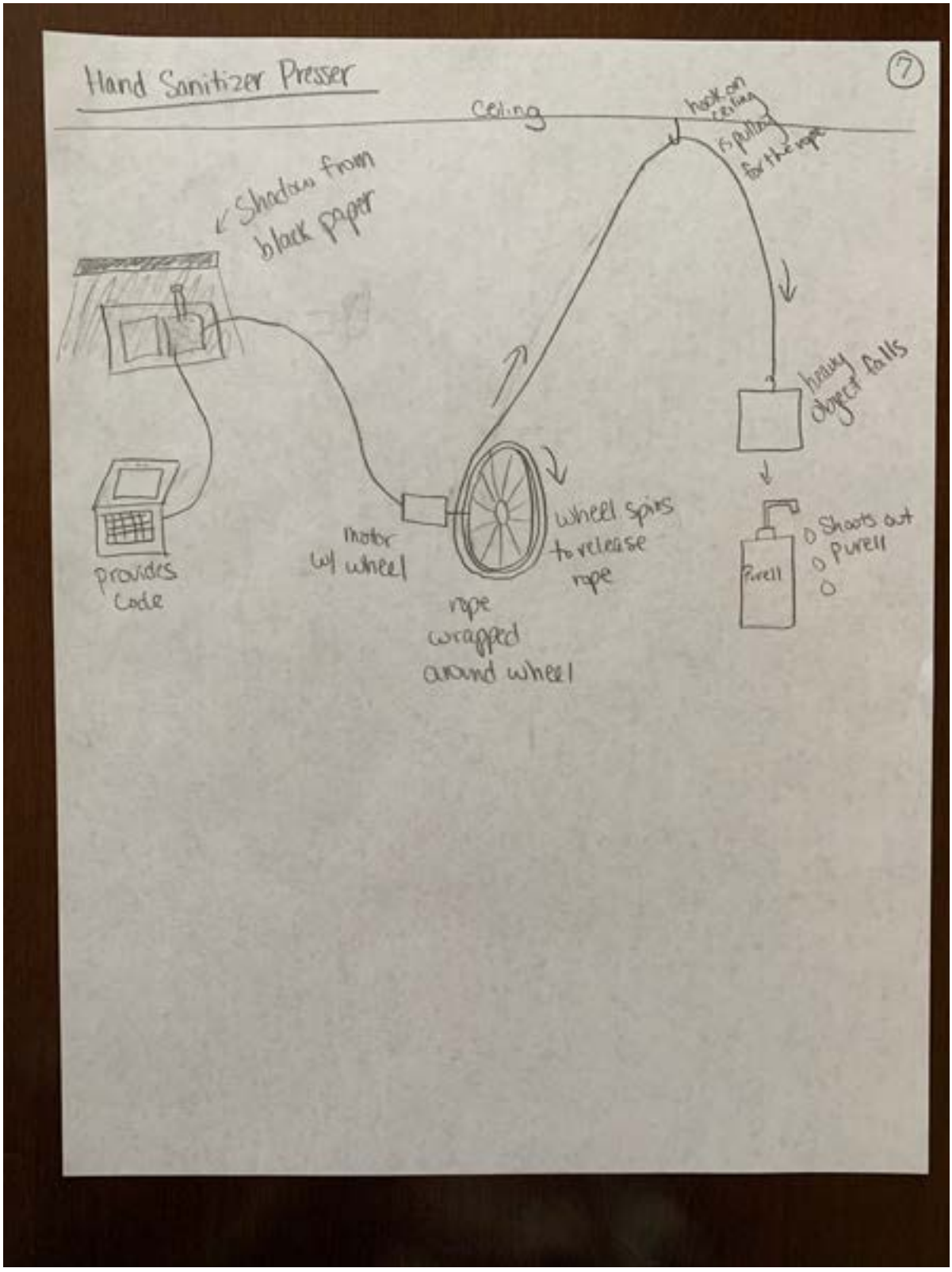
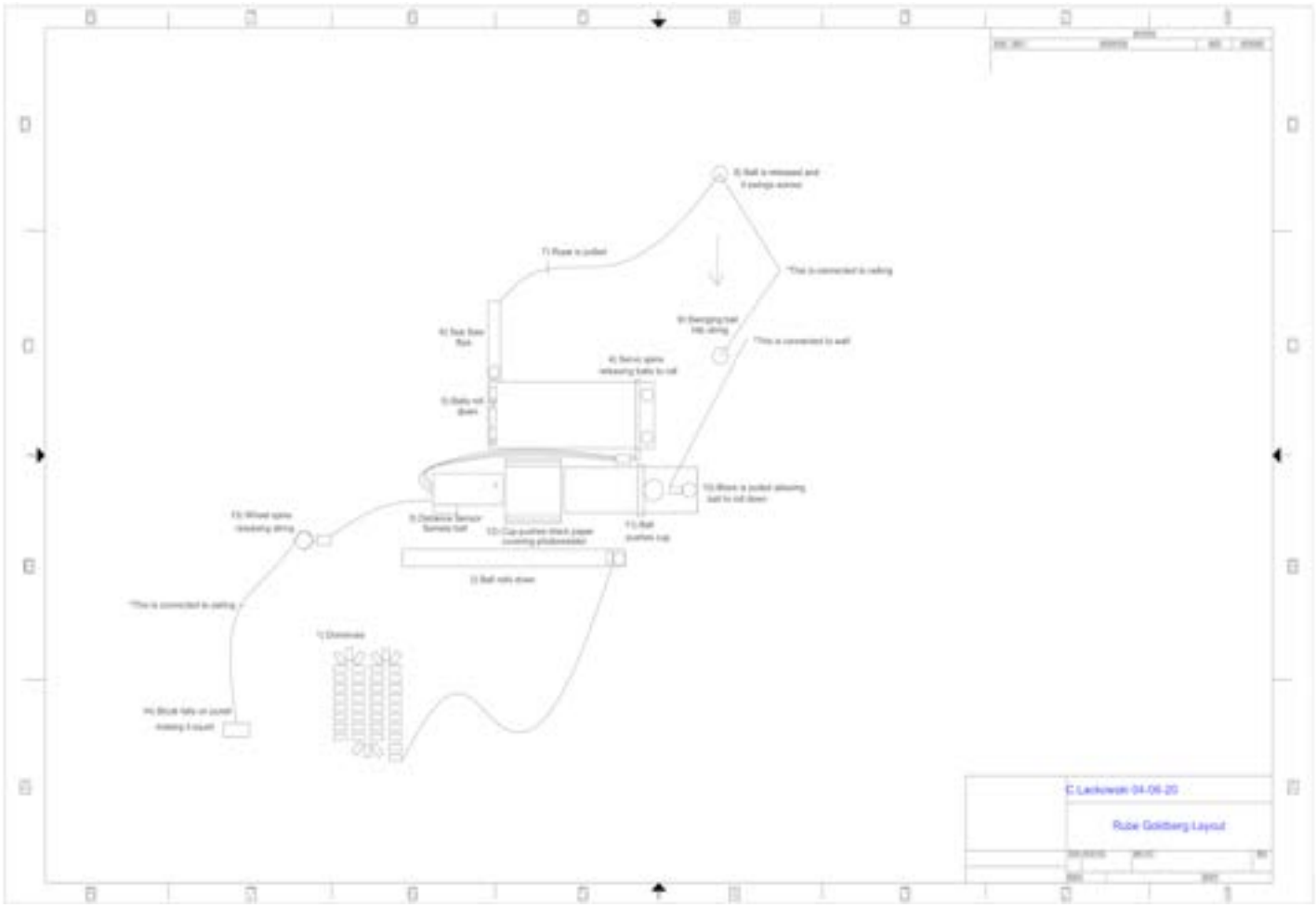


Figure 12 AutoCAD Design Layout



Appendix C – Photo Log

Figure 13 Dominoes Stage

Figure 14 Rolling Balls Stage

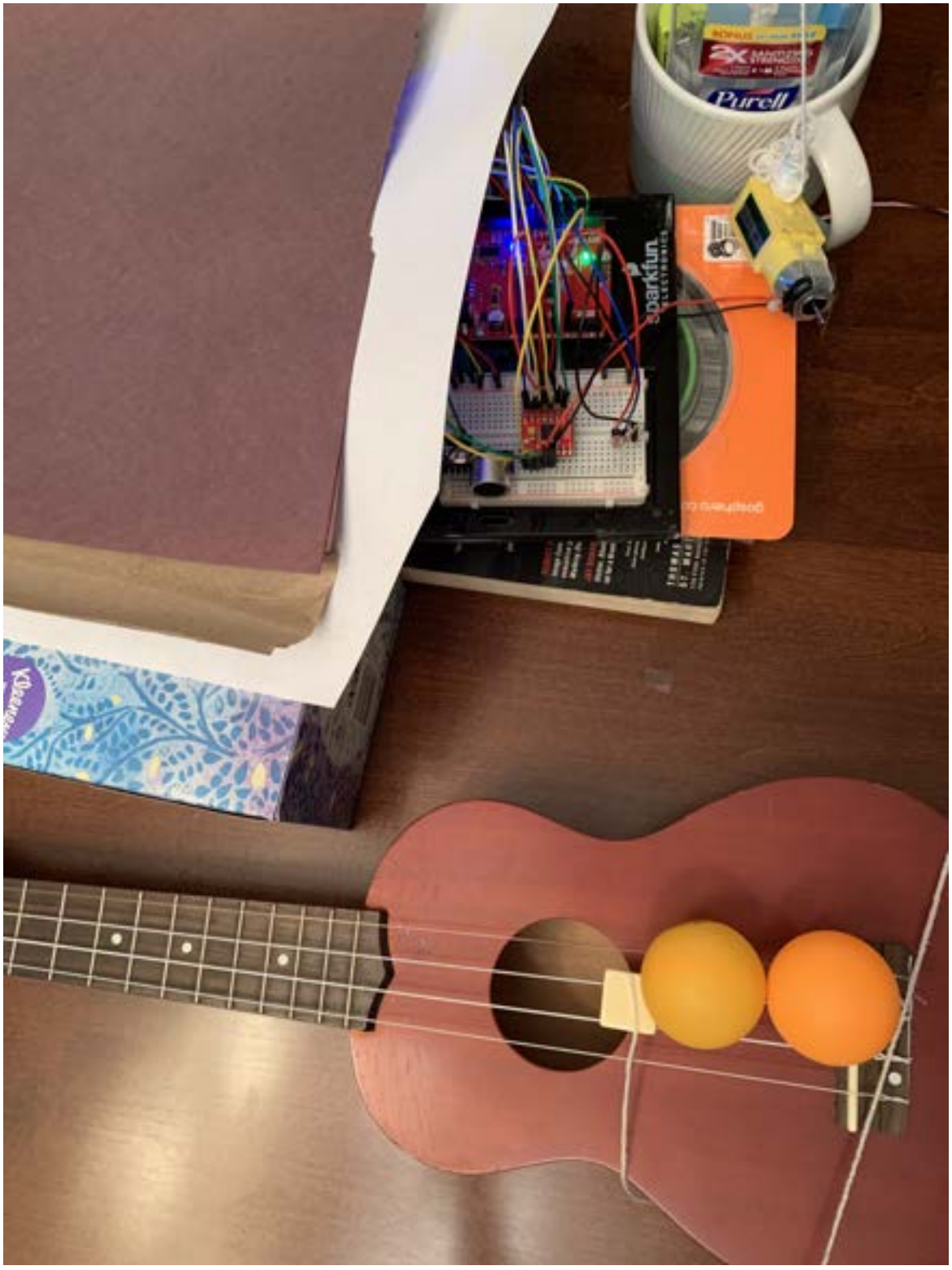


Figure 15 Servo Stage

Figure 16 Seesaw Stage

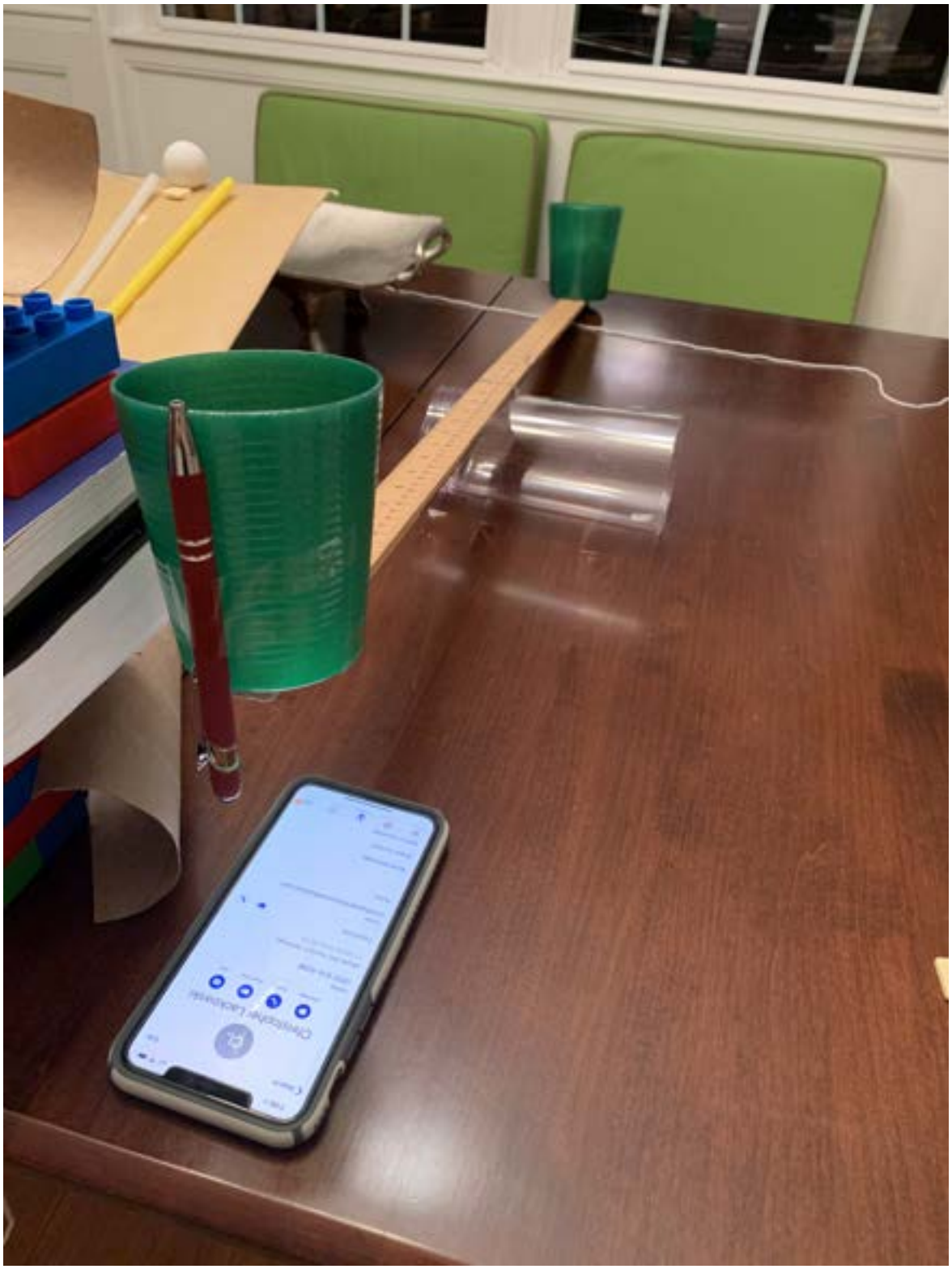


Figure 17 Swinging Ball Stage

Figure 18 Photoresistor Stage

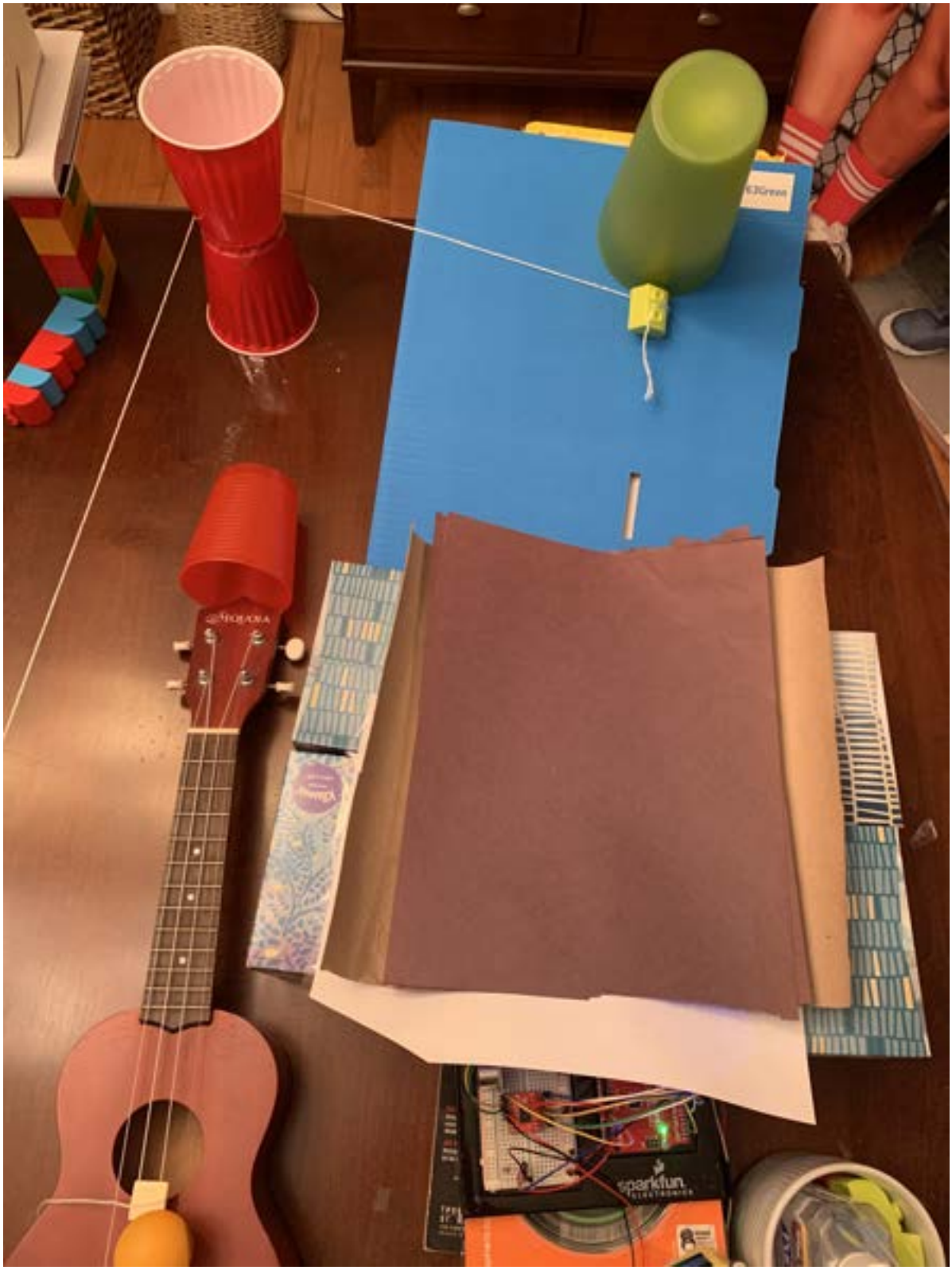


Figure 19 Hand Sanitizer Squirter Stage

Figure 20 Large View of Final Machine

Appendix D – Final Results

Figure 21 Youtube Link to Video of Working Machine

https://www.youtube.com/watch?v=VaI0rGVCkWs

Appendix E – Final Budget

Table 1 Final Budget of the Device

Item	Unit Value	Units	Qty	Value	Cost	Source
Boxes	$0.00	ea	10	$0.00	$0.00	My house
Ping pong balls	$0.40	ea	12	$4.80	$0.00	My house
Cup	$0.49	ea	1	$0.49	$0.00	My house
Dominoes	$0.20	ea	100	$20.00	$0.00	My house
String	$16.00	rolls	1	$16.00	$0.00	My house
Paper Towel Rolls	$0.00	ea	6	$0.00	$0.00	My house
Tape	$1.99	rolls	1	$1.99	$0.00	My house
SparkFun Components	$79.99	ea	1	$79.99	$0.00	My house
Computer	$1,000.00	ea	1	$1,000.00	$0.00	My house
Lego Blocks	$1.00	ea	30	$30.00	$0.00	My house
			Total:	$1,153.27	$0.00	