

GNG1103
Final Design Report

Distorted View

Submitted by

Group F7

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Abstract

Engineers and artists have been known for their stark differences in design styles. This project was the result of the collaboration between a group of undergraduate students from the Faculty of Engineering and the Faculty of Arts, coming together to create an interactive art sculpture.

This document outlines the work done by group F7 for the art installation project of GNG1103 (Engineering Design). During the semester the group worked with a group of artists from Recycl'Art, who have an annual exhibition for showcasing recycled art pieces. The engineering design process learned in the course was used and the specific steps which include needs identification, conceptual design, design analysis, and prototyping have all been described in great detail in the report. Other information such as the budget and materials have also been included in this comprehensive final report.

Table of Contents

Abstract.....	i
Table of Contents	ii
List of Figures	iv
List of Tables	vii
1 Introduction.....	8
2 Need Identification and Product Specification Process	9
3 Conceptual Designs	14
4 Project Plan, Execution, Tracking & Bill of Materials.....	19
5 Analysis:	23
6 Prototyping, Testing and Customer Validation.	25
7 Conclusions and Recommendations for Future Work	37
8 Bibliography	38
APPENDICES	39
APPENDIX I: User Manual.....	40
APPENDIX II: Design Files	42

List of Figures

Figure 1: Dropping the dam(n), Strandbeest, CD animal sculpture (respectively)	11
Figure 2: Rotating Umbrellas.....	14
Figure 3: Pressure sensor stairs.....	15
Figure 4: Gyrating Structure	16
Figure 5: Gantt chart	19
Figure 6: Cardboard prototype side view, Cardboard prototype back view	26
Figure 7: Cardboard prototype front view	27
Figure 8: 3D printed prototype front view	28
Figure 9: 3D printed prototype back view	29
Figure 10: 3D printed prototype top view.....	29
Figure 11: Circuit constructed in Tindercad	31
Figure 12: Physical circuit	31
Figure 13: Arduino code	32
Figure 14: Prototype 2 large disc	32
Figure 15: Small disc with motor and dowel.....	34
Figure 16: Prototype 3 large disc	34
Figure 17: Backdrop	35
Figure 18: pcp board	36
Figure 19: Final design	41



List of Tables

Table 1: Needs Identification.....	9
Table 2: Benchmarking.....	11
Table 3: Design Specifications	12
Table 4: Evaluating Benchmarked Sculptures	13
Table 5: Evaluating Conceptual Designs	17
Table 6: Up-to-date Task Chart	21
Table 7: Bill of Costs and materials.....	22
Table 8: Design Specifications	23
Table 9: calculations table.....	24
Table 10: Parts list	41

1 Introduction

Recycling is a major issue worldwide, and with the never-ending cycle of consumerism we see many materials turned to waste before reaching their full potential. Art has always been a medium for expression, and this project uses skills from both engineering and art to promote recycling and collaboration between the engineering and art disciplines. The clients, a group of artists from the Recycl'Art art exhibition, asked our group to create an art sculpture using mostly recycled material. The task was to create a sculpture that was not only visually appealing but had to have a kinetic function, be composed of at least 80% recycled materials, cost less than \$100, and have an interesting theme. The ultimate goal was to create a sculpture with the intent of showcasing it in their annual exhibit for recycled art pieces.

A task as creatively inclined as this is bound to have many possibilities for a “solution”. What makes our design distinct from the others is the use of rotational dynamics and reflective surfaces that capture the viewer's eye while interacting with them. This visual combination leads to an interesting distortion of the viewer and light; hence the name: “Distorted View”.

2 Need Identification and Product Specification Process

The first client meeting was in the form of a presentation by the group of artists from Recycl’Art. We learned about their experiences (both individual experiences and experience with Recycl’Art) and what they hoped to see from us at the end of the project duration. The following table outlines the things we were told and our subsequent interpretations of the client statements into specific needs.

<i>Ranking (1 = most important)</i>	<i>Client statement</i>	<i>Interpreted need</i>
4	Recycl’art will be moving their exhibition around from location to location.	The art sculpture will be easily transportable from place to place.
1	Recycl’art promotes recycling by showcasing how objects can be reused artistically.	The art piece will convey the theme of recycling , by being made of at least 80% recycled material.
3	They are really excited to see what innovative designs we will make.	The art piece will be creative and original .
3	They want the piece to “touch the life of others”.	The art piece will capture the attention of visitors to the exhibition and leave a positive impact on them. The art piece will make an emotional connection with the viewers.
2	The art piece will have a public location.	The art piece will be safe and non-hazardous to the health of anyone in the vicinity.
2	The art installation should be interactive.	The art sculpture will have a feature which enables it to interact with its surrounding environment (either humans and/or nature).
5	The piece can be showcased outdoors or indoors.	If outdoors is chosen, then the art sculpture will not collapse under outdoor conditions such as wind (weather resistance).

Table 1: Needs Identification

After identifying the basic needs for the product we came up with the following problem statement: A need exists for Recycl’Art to exhibit an **innovative** art piece made with a budget of \$100, that uses **recycled** materials to create something **eye-catching** which will leave a **positive impact** on the viewers who visit the exhibition.

Need Identification and Product Specification

The problem statement for our project is evidently less restrictive/specific compared to the usual engineering design problems seen in the GNG1103 course. This is due to the creative freedom that came with doing an art sculpture.

Benchmarking was done during this stage of the design process to analyse pre-existing sculptures and learn from their strengths and weakness.

→ Sculpture Specifications ↓	“Droppings and the Dam(n)”	“Strandbeest”s	CD Animal sculptures
Artist	Arunkumar H.G.	Theo Jansen	Sean Avery
Cost (\$)	~0	> 0	~0
Recycled material (%)	~99	~60	~95
Weight (lb)	~250	77-330	~10
Size: entirety fits through a doorway	No	No (16ft long, 6.5ft wide, and 10ft High)	Yes
Eye-Catching	Medium	Very High	High
Interactive	No	Yes	No

Need Identification and Product Specification

Safety: No sharp surfaces	Yes	Yes	No
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Table 2: Benchmarking

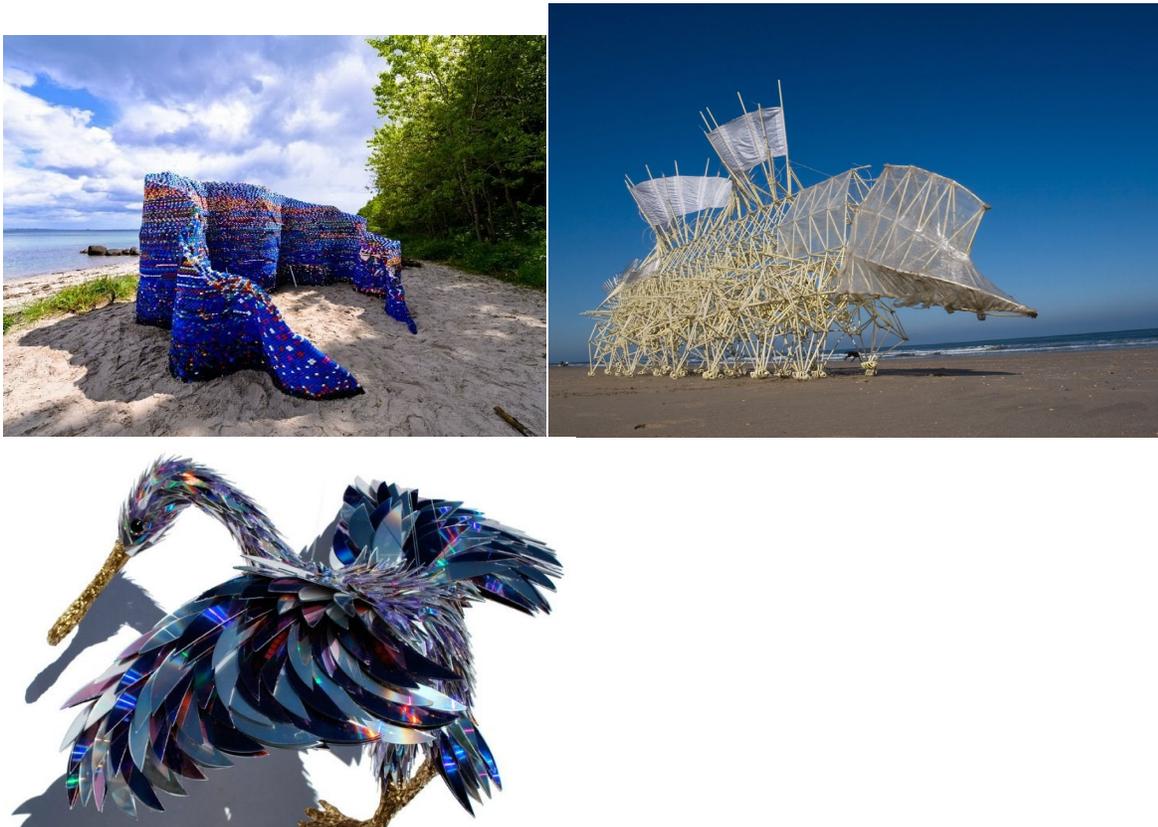


Figure 1: Dropping the dam(n), Strandbeest, CD animal sculpture (respectively)

Having identified the user/customer needs, we were able to come up with the following table for the design criteria where all our target specification has been identified.

	Design Specifications	Relation (=, <, >)	Value	Units	Verification Method
	Functional Requirements				
1	Interactive	=	Yes	N/A	Testing

Need Identification and Product Specification

2	Eye-catching	=	Yes	N/A	Outside perspective
3	Non-hazardous	=	Yes	N/A	Testing
Constraints					
1	Made of recycled material	>=	80	%	Keeping track of material
2	Height	>=, <=	2, 6	ft	Testing
3	Width	>=, <=	2, 3	ft	Testing
4	Weight	<	150	lb	Testing
5	Cost	<=	100	\$	Keeping track of purchases
Non-Functional Requirements					
1	Product life	>	4	months	Time will tell
2	Durable (weather resistant)	=	Yes	N/A	Testing

Table 3: Design Specifications

e →	Sculptur	Importance (weight)	“Droppings and the Dam(n)”	“Strandbeest”s	CD Animal sculptures
Specifications ↓					
Artist			Arunkumar H.G.	Theo Jansen	Sean Avery
Cost (\$)		2	3	2	3
Recycled material (%)		4	3	1	2

Need Identification and Product Specification

Weight (lb)	1	1	2	3
Size: entirety fits through a doorway	2	2	2	3
Eye-Catching	3	1	3	2
Interactive	4	2	3	2
Safety: No sharp surfaces	2	3	3	2
Total points		40	41	41

Table 4: Evaluating Benchmarked Sculptures

The table above shows how each benchmarked art sculpture performs when compared with our metrics. From these results we observed that the two most successful art pieces were either interactive (Strandbeest) or very visually appealing and reflective (CD animal sculpture).

3 Conceptual Designs

Many designs and ideas were formatted by each team member during the brainstorming stage of the design process, however only three were chosen for further analysis according to group consensus.

3.1 Rotating Umbrellas

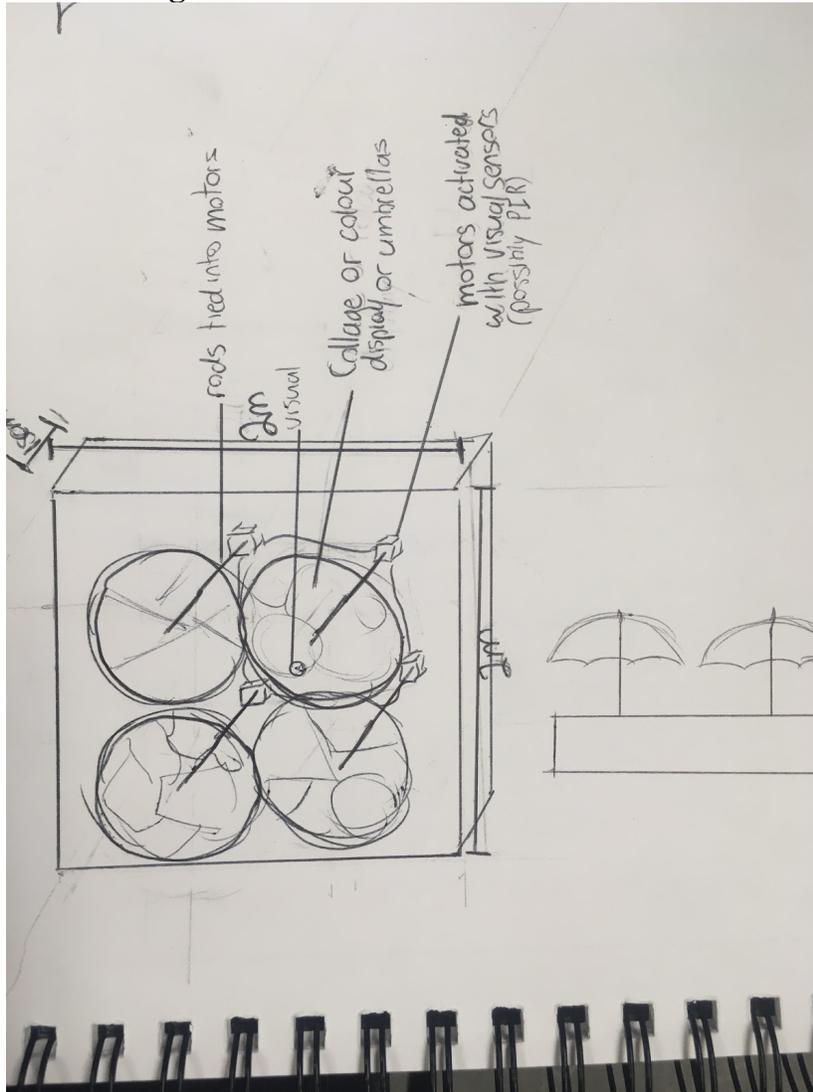


Figure 2: Rotating Umbrellas

Features:

- Motion sensor and Arduino board
- 4 “umbrellas” that rotate in response to detected motion
- Max Price = $4 \times \$10$ (motors) + \$25 (Arduino) + \$10 (sensor) + \$20 (aesthetics) = \$95 + taxes
- Disassemble

Drawbacks:

- Display is from one direction only
- Price

Advantages:

- Visually aesthetic
- Eye catching
- Kinetic
- Interactive

3.2 Pressure sensor stairs

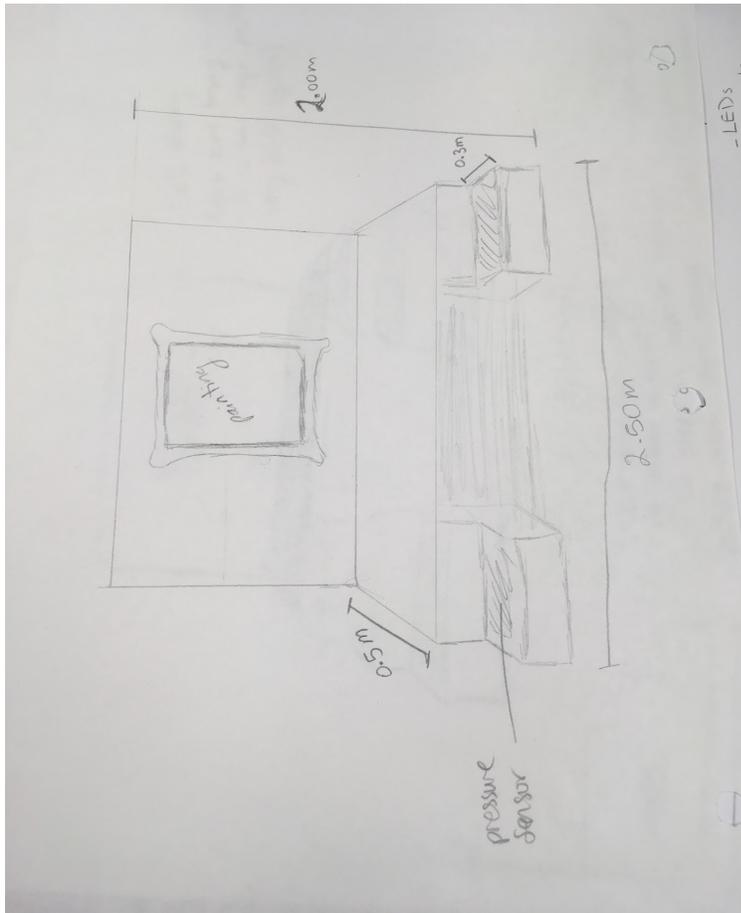


Figure 3: Pressure sensor stairs

Features:

- Pressure sensors (x2)
- Stereo for sound
- 2 Stairs with pressure sensors which trigger sound when individuals walk up the stage
- Max Price: \$25 (Arduino) + 2 x \$10 (pressure sensor) + \$20 (aesthetics) = \$65 + taxes
- Backdrop has a painting display to capture the attention of passersby

Drawbacks:

- Not very sculptural or aesthetically appealing
- Big and Bulky structure (heavy too)

Advantages:

- Availability of materials
- Interactive
- Kinetic

3.3 Gyrating structure

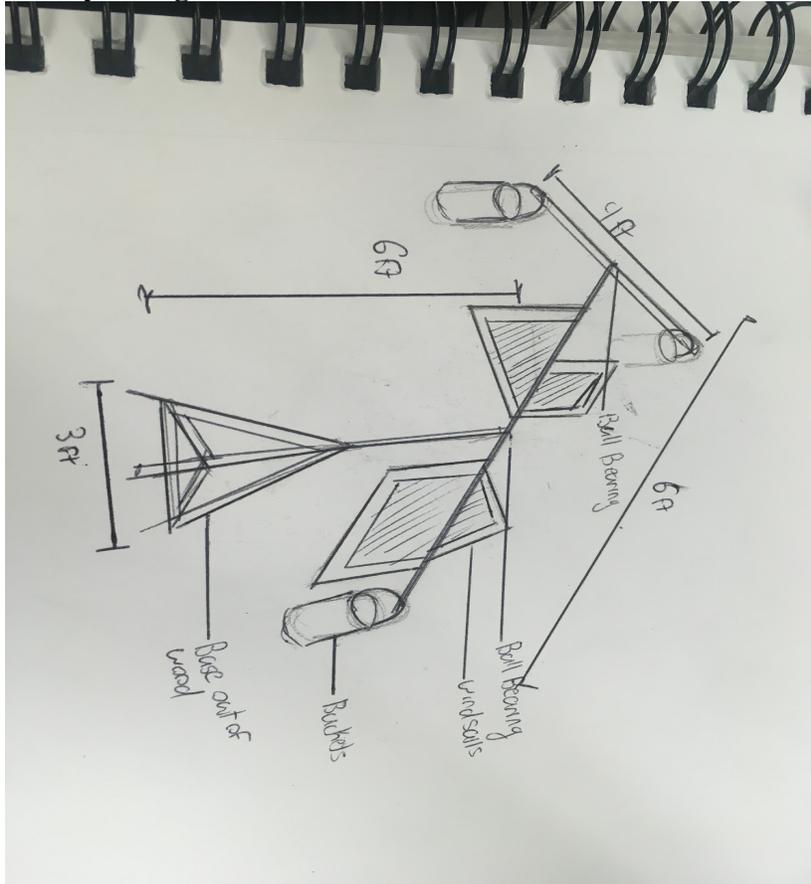


Figure 4: Gyrating Structure

Features:

- Price = \$6 (ball bearings) + \$20 (paint/aesthetics) = \$26 + taxes
- disassemble

Drawbacks:

- No aesthetic appeal

Advantages:

- Availability of materials
- Price
- Simplicity

3.4 Concept Analysis and Evaluation

Sculpture →	Importance (weight)	Rotating Umbrellas	Gyrating Structure	Pressure sensor stairs
Specifications ↓				
Cost (\$)	2	~ 92	~ 26	~65
Recycled material (%)	4	90	99	90
Weight (lb)	1	~20	50-100	200+
Size: entirety fits through a doorway (or disassemble)	2	Yes	yes	yes
Eye-Catching	3	Very	Somewhat	Adequate
Interactive	4	Yes	No	Yes
Safety: No sharp surfaces	2	Yes	Yes	Yes
Total points		46	39	43

*Note: GREEN - 3 pts YELLOW - 2 pts RED - 1 pt

Table 5: Evaluating Conceptual Designs

Based on the analysis of the three solutions using pre-established design criteria, and a final voting process, the chosen solution was “Rotating Umbrellas”. This design is eye-catching, disassemble (transportable), and interactive (motion triggered rotation of umbrellas). The team voted to pursue the umbrella design against the pressure sensor stairs, because it seemed easier to execute and transport.

4 Project Plan, Execution, Tracking & Bill of Materials

In order to finish the sculpture on time for Design Day a project schedule was created early on before any prototyping had begun. This was achieved using both a table of tasks and a Gantt Chart in Microsoft Project.

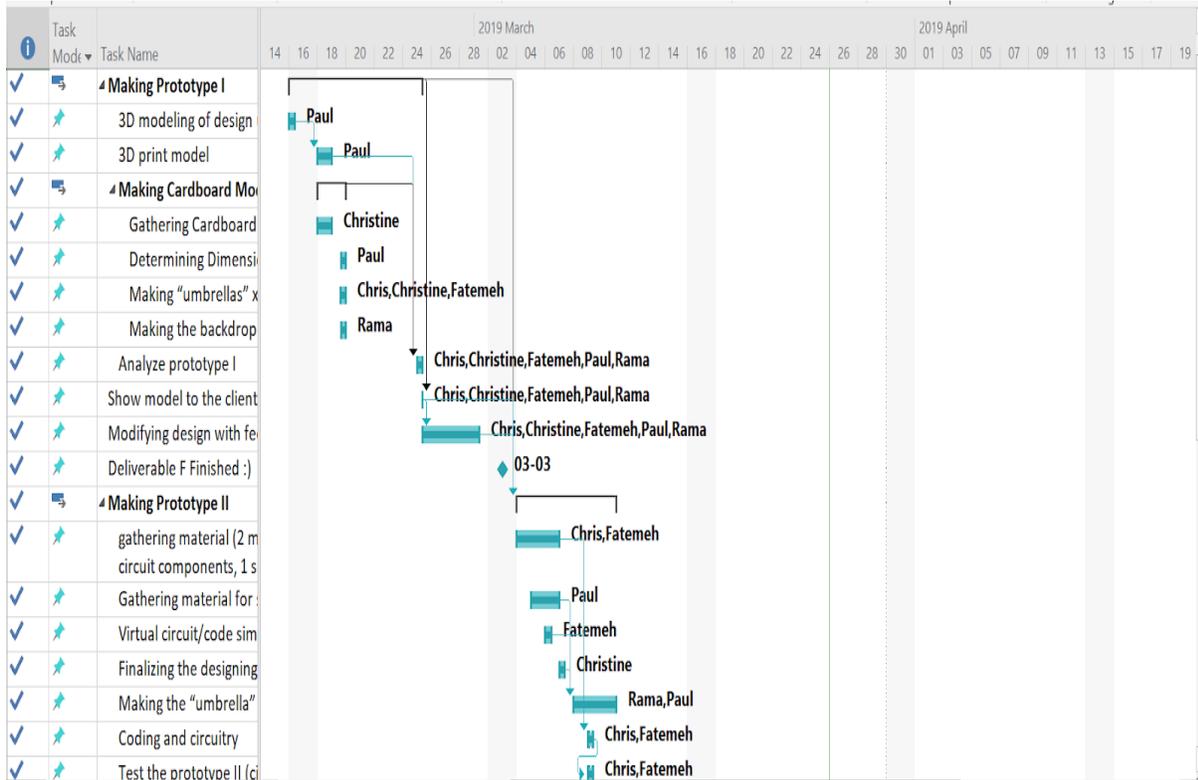


Figure 5: Gantt chart

The table of tasks was updated as the project progressed in order to capture the actual finish dates for the tasks and keep track of the people who completed them.

Task	Estimated Duration	Owner	End Date
Determining theme of art sculpture	2 hr	All	Done Feb 14
Prototype I			
3D modeling of design using CAD	2 hr	Paul	Done Feb 16

3D Print the Model	1 day (overnight)	Paul	Done Feb 19
Cardboard model			
Gathering Cardboard	1 day	Christine	Done Feb 18
Determining Dimensions of model	1 hr	Paul	Done Feb 19
Making “umbrellas” x4	2 hr	Fatemeh & Christine & Chris	Done Feb 19
Making the backdrop	1 hr	Rama	Done Feb 19
Analyse Prototype I	1 hr	All	Feb 25
Show model to the client and receive feedback	20 min	All	Feb 26
Modifying design based on feedback from prototype I	1 hr	All	Done Feb 28
Submit project deliverable F	2 hr	Fatemeh	Mar 3
Making Prototype II			
Getting material (2 motors, Arduino and circuit components, 1 sensor) for 2nd prototype	1 week	Chris & Fatemeh	Done March 7
Gathering material for structure (plywood and plastic)	1 day	Paul	Done Mar 7
Programming the Arduino board + making the circuit	3 days	Fatemeh & Chris	Done Mar 9
Making two of the discs (“umbrellas”)	1 day	Rama, Christine	Mar 8
Designing for the discs	1-3 days	Christine	Done Mar 8
Testing/Analyzing prototype II	1 hr	All	Mar 9
Submit Project Deliverable G	2 hr	Fatemeh	Mar 10
Show model to the client and receive feedback	5 min	All	Mar 13

Refining the design based on feedback	1 hrs	All	Mar 14
Making Prototype III			
Purchase all remaining material	1 week	Chris	Done March 26
Determining final exact dimensions	30 min	Paul	Done Mar 14
Obtaining plywood and plastic	1-2 hrs	Paul	Done March 7
Making backdrop + base (to hold it up)	3 hrs	Paul	Done Mar 22
Making umbrellas	3 hrs	Rama & Fatemeh & Christine	Done Mar 22
Final Code and circuit system	2 days	Chris & Fatemeh	Done Mar 22
Assemble all parts together	2 hrs	Chris, Fatemeh, Paul, Rama	Done Mar 27
Testing the Prototype	2 hrs	Chris, Fatemeh, Rama	Done Mar 28
Finish Project Deliverable H	2 hr	All	Done Mar 24

Table 6: Up-to-date Task Chart

Along with project tasks, the project costs were also tracked throughout the whole process to make sure the constraint of \$100 was met and to keep track of all the material used for creating the art sculpture.

Item	Amount	Unit Cost (\$)	Cost (\$)
Dual H-Bridge			13.11
12V power supply			12.99
Batteries			7.09
High Torque motor (Amazon)			13.19
DC Motors (makerlab)	2	9	18
Ultrasonic Sensor	1	4	4
Protoboard	1	0.6	0.6
Arduino (makerlab)	1	13	13
mosfet	1	1.5	1.5
resistor	1	0.15	0.15
breadboard	1		2.5
TOTAL			86.13

Table 7: Bill of Costs and materials

The recycled materials used in the project are the following: recycled plywood, recycled CDs, plastic lunch trays, and recycled electrical wires.

5 Analysis:

For our project through every step of our design process we were constantly evaluating our specifications so that we gave our clients a design that they agreed upon. After our second client meeting, they gave us more ideas for refining our project so that it had an interesting theme and a design that everyone liked. After that meeting, we finalized our design specifications into the table below.

	Design Specs	Relation (=, <, >)	Value	Units	Verification Method
Functional Requirements					
1	Interactive	=	Yes	N/A	Testing
2	Eye-catching	=	Yes	N/A	Outside perspective
3	Non-hazardous	=	Yes	N/A	Testing
Constraints					
1	Made of recycled material	>=	80	%	Keeping track of material
2	Height	>=, <=	2, 6	ft	Testing
3	Width	>=, <=	2, 2.5	ft	Testing
4	Weight	<	150	lb	Testing
5	Cost	<=	100	\$	Keeping track of purchases
Non-Functional Requirements					
1	Product life	>	4	months	Time will tell
2	Durable (weather resistant)	=	Yes	N/A	Testing

Table 8: Design Specifications

Specifications of the Motor	Value of Specifications and Units
Motor Voltage	6.0V
Rated load speed	13000 \pm 10%rpm
Rated load current	408mA=0.408A

Torque	$\left(\left(\frac{6.0V \cdot 0.408A}{746(W/HP)}\right) \cdot 5252\right) / 13000rpm$ $= 1.33 \cdot 10^{-3} \text{pound-feet of torque}$
--------	--

Table 9: calculations table

The max current that will be going through each individual circuit will be $1.6 \cdot 10^{-2}A$. This was calculated because we know that the formula for calculating resistance in a parallel circuit is:

$$1/R_T = 1/R_1 + 1/R_2 + 1/R_3 \dots 1/R_n$$

So, the calculated total resistance of the circuit is 550Ω because each resistor in the circuit has a value of $2.2k\Omega$. The total voltage of the circuit is $9V$ because the batteries we are using to supply the circuit are rated at $9V$. So finally, the formula for the current is:

$$I = V/R$$

Thus, when you divide the total voltage of the circuit by the total resistance of the circuit, we have the value of the current which is $1.6 \cdot 10^{-2}A$.

6 Prototyping, Testing and Customer Validation.

For our first prototype we decided to make two physical comprehensive models to demonstrate a rough view for the direction we wanted to take the project. The first of the two models were a 3D printed model that shows our complete design including what the wiring would look like on the back. Our second model was made of cardboard and toothpicks, the cardboard being used for the back drop and four spinning discs and the toothpicks used as dowels. The purpose of our second model was to show a little bit of functionality and to show how we wanted the discs to spin as people walking in front of our sculpture.



Figure 6: Cardboard prototype side view, Cardboard prototype back view

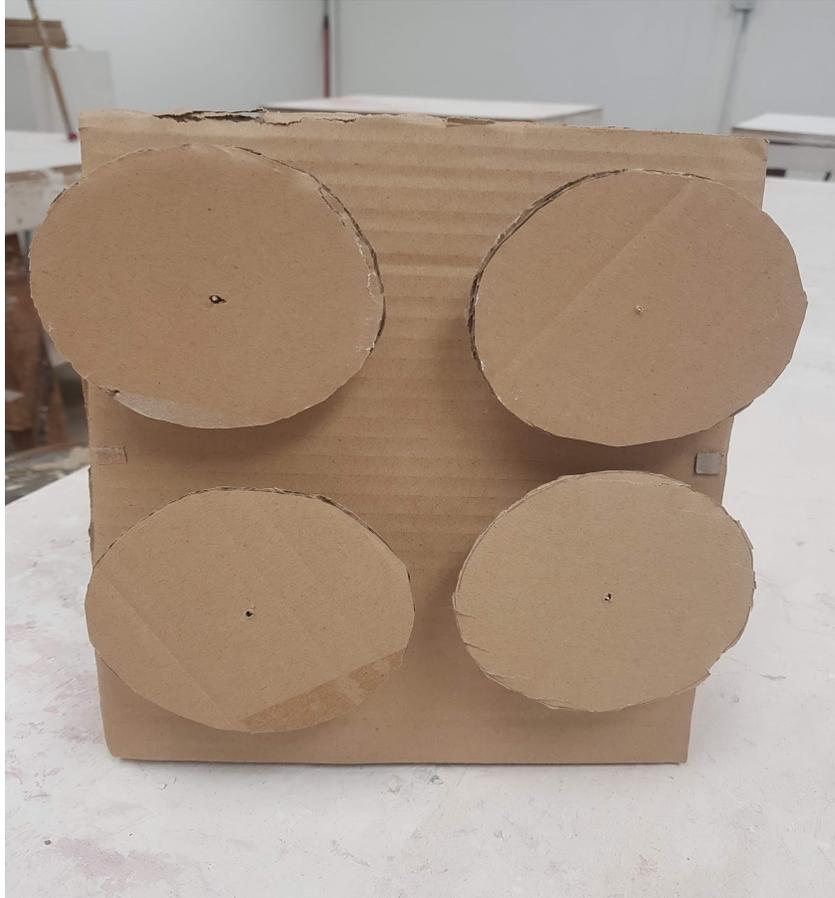


Figure 7: Cardboard prototype front view

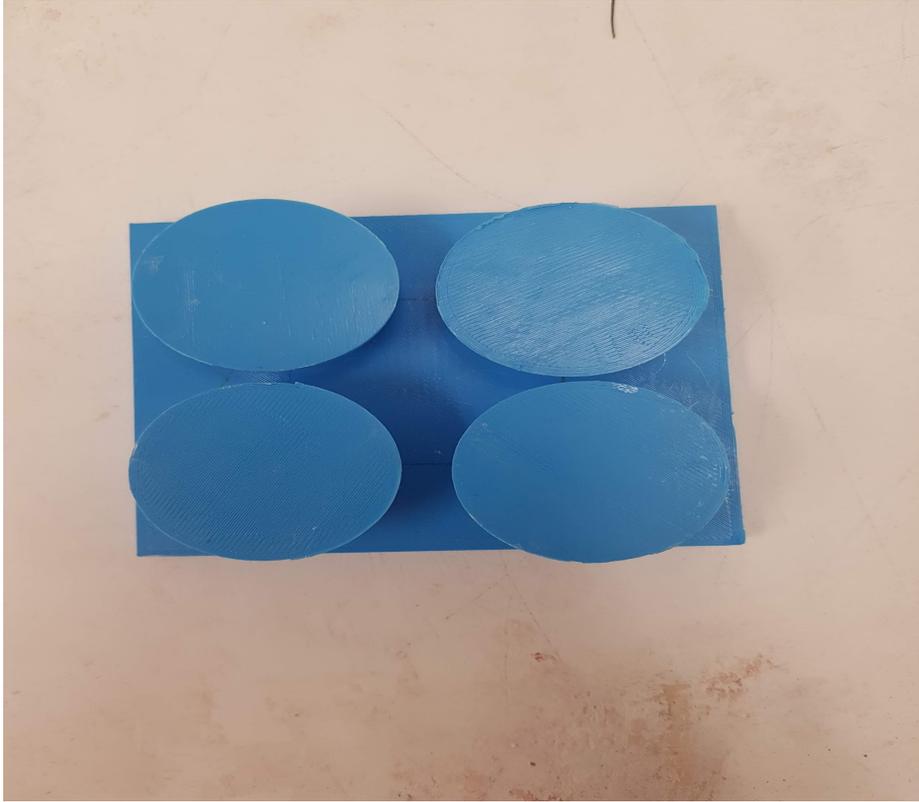


Figure 8: 3D printed prototype front view



Figure 9: 3D printed prototype back view

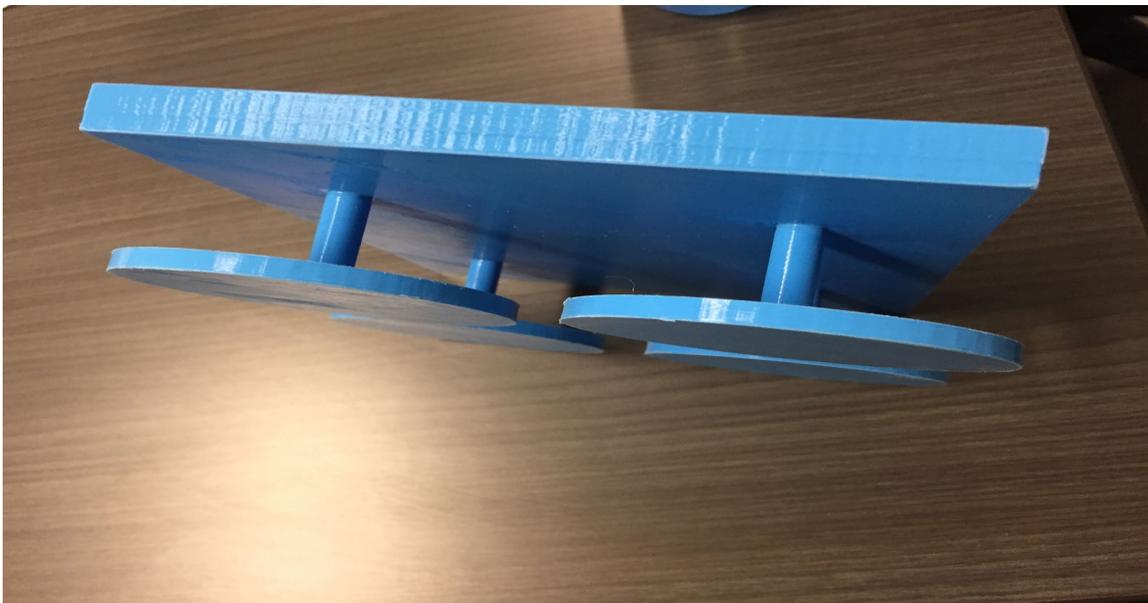


Figure 10: 3D printed prototype top view

For our second prototype we wanted to demonstrate the functionality of our design and create a larger scale disc to show a better representation of our final product. To show our functionality we created a circuit in Arduino that would change the speed of one of our motors according to how close the object was in front of our sensor. In addition to creating the circuit we also created the larger disc and added some of our recycled CD's to give an idea of what the disc in our final prototype would look like. The purpose of this prototype was to test our subcomponents to make sure that they worked on a smaller scale so that we wouldn't waste resources for our final prototype.

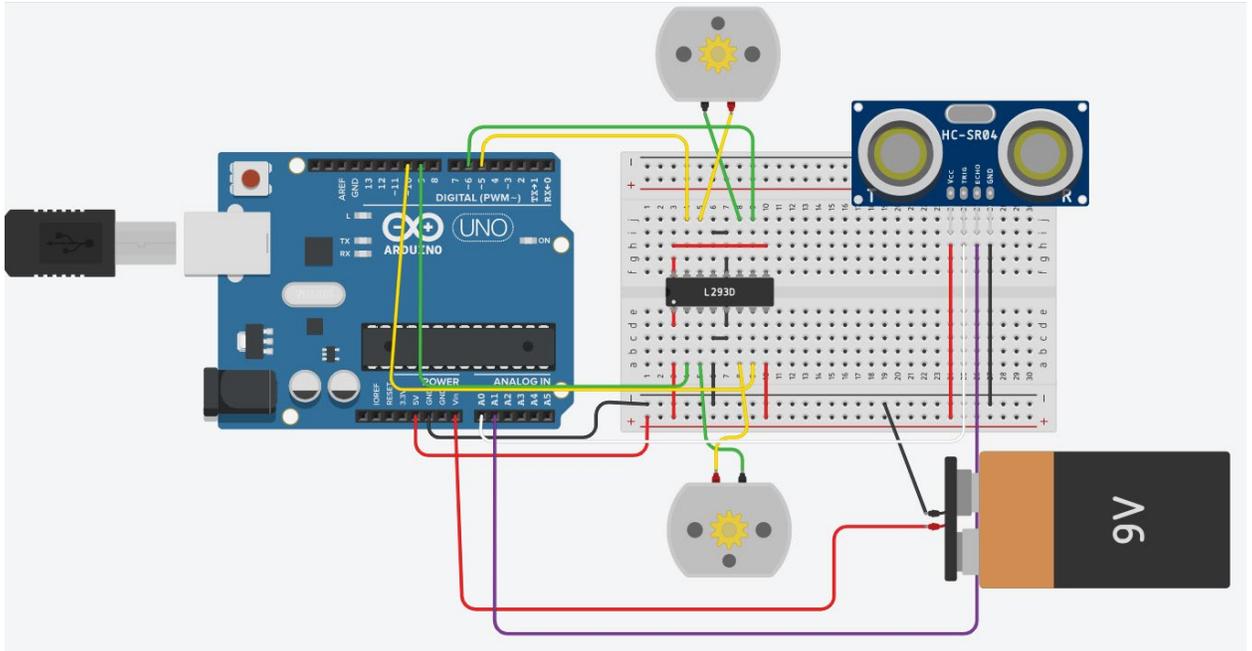


Figure 11: Circuit constructed in Tindercad

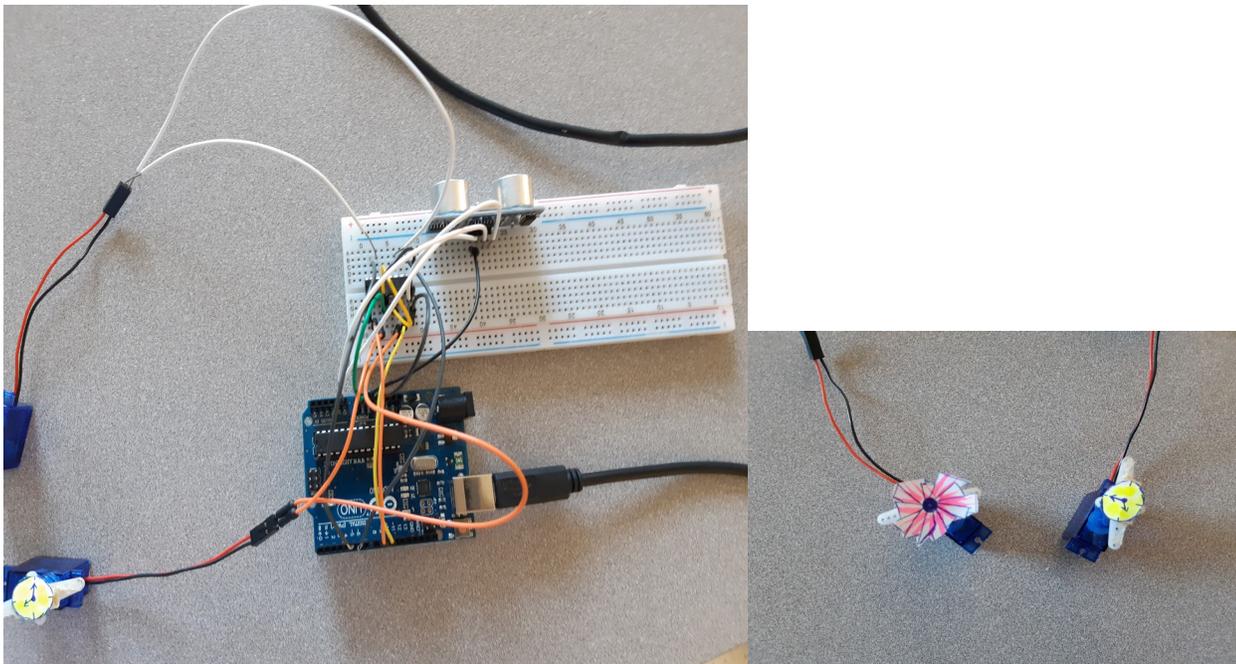


Figure 12: Physical circuit

```
Upload
Final_Code

//Motor A
const int motorPin1 = 10; // Pin 7 of L293
const int motorPin2 = 9; // Pin 2 of L293

//Motor B
const int motorPin3 = 5; // Pin 14 of L293
const int motorPin4 = 6; // Pin 10 of L293

#define TRIGGER_PIN A0
#define ECHO_PIN A1
#define MAX_DISTANCE 200 //in cm

NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE);

void setup() {
  //Set pins as outputs
  pinMode(motorPin1, OUTPUT);
  pinMode(motorPin2, OUTPUT);

  pinMode(motorPin3, OUTPUT);
  pinMode(motorPin4, OUTPUT);

  Serial.begin(9600);
}

void loop() {
  //half speed start
  analogWrite(motorPin1, 255/3);
  analogWrite(motorPin2, 0);
  analogWrite(motorPin3, 255/3);
  analogWrite(motorPin4, 0);

  int distance = sonar.ping_cm();
  Serial.print("Distance: ");
  Serial.println(distance);

  while (distance < 5)
  {
    analogWrite(motorPin1, 255);
    analogWrite(motorPin2, 0);
  }
}
```

Figure 13: Arduino code



Figure 14: Prototype 2 large disc

For our final prototype, our goal was to test and implement all our subcomponents of our project and make revisions so that in the end we would have a fully functional prototype. To do this we created our backdrop using recycled plywood and painted it gray so that it would not take anything away from the rotating discs. For our discs we added more recycled CD's onto the previous disc from prototype two and created more supports so that it would stay together, as well we created the other smaller disc which we painted black to contrast our bigger disc. Additionally we attempted to implement our motors with our discs and ran into some issues with our larger disc being too heavy for our motor. To try to solve this we bought another motor with higher torque in hopes that it would be able to support the weight. In the end we were not able to find a motor that would support the weight of our disc, so we reached out to the art professors and they said that it was more important that the disc was its size than for it to be rotating. So, with that feedback we made our larger disc static to satisfy the art's professors. Finally, we also soldered our circuit onto a pc board so that it would be more functional during design day.



Figure 15: Small disc with motor and dowel



Figure 16: Prototype 3 large disc



Figure 17: Backdrop

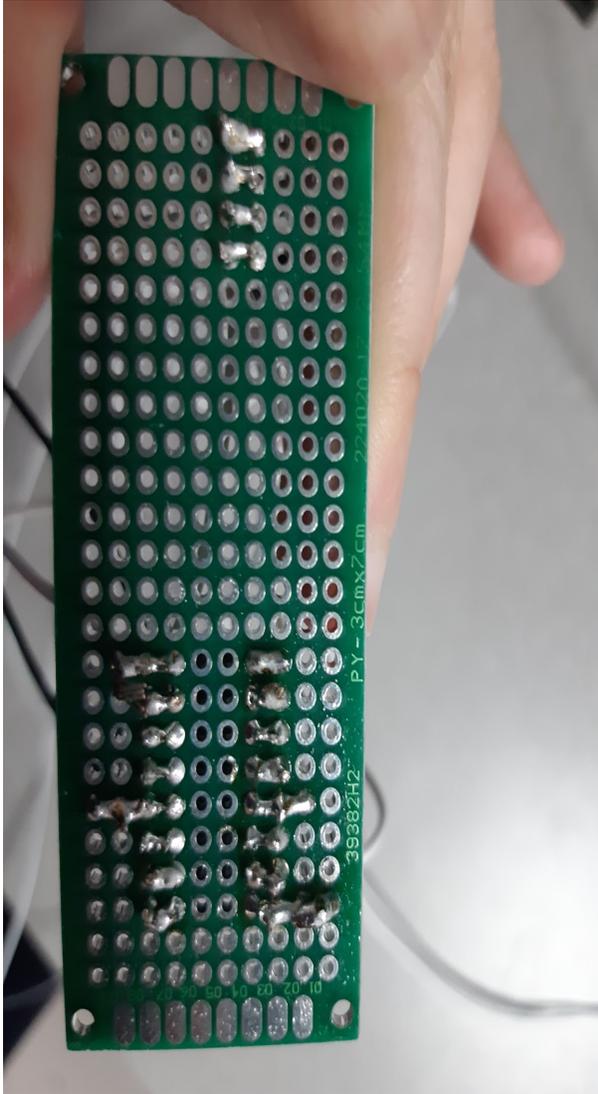


Figure 18: pcb board

8 Bibliography

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Alter, Lloyd. "Strandbeests Blowin' In The Wind." *TreeHugger*, Treehugger, 11 Oct. 2018.

Arunkumar H G. "Droppings and the Dam (Damn)." *Arunkumar H G*, 8 Mar. 2018.

APPENDICES

APPENDIX I: User Manual

- **Installation**

To install this project all you need to do is plug it in everything stays together while it is being transported.

- **Safety guidelines**

Do not touch sculpture while it is in use and when transporting make sure to have several people to transport it.

Parts List	Functions and capabilities
DC motor (low torque)	Spins the smaller disc and has the ability to change speed
DC motor (high torque)	Spins the larger disc at a constant speed
Ultrasonic sensor	Detects how close an object is from the sculpture, has a range of 0-4m
Large disc	Spins at a consistent speed and is covered in CD's
Small disc	Has a fast and slow mode
Arduino	Controls the signals sent from the ultrasonic sensor to the motors and has the code for the circuit inside it

Table 10: Parts list



Figure 19: Final design

APPENDIX II: Design Files

All design files, such as code and diagrams, can be found at:
<https://makerepo.com/FatemehMK/gng1103f7distorted-view>