Project 1 Final Reports

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Team 8

Abstract

Our task at hand for this project was to redesign an electric toothbrush that caters to various customer needs. We began with assembling a list of consumer needs and then developed a survey to provide us with further knowledge as to what kind of changes we wanted to make. After learning that aesthetics and brush technology is important to our customers, we came up with possible changes we could make in order to allow our toothbrush to appeal to a wider range of customers.

For our new product, we are going to use the same material as the previous model we worked with. Our first big change would be to utilize a rechargeable battery that plugs into the wall rather than conventional lithium batteries. We feel this is much more convenient especially when one is on the road. We also decided we would implement a dual rotating brush-head (each spinning in opposite directions) to provide a more effective cleaning. Lastly, we want to improve the aesthetics by providing a more comfortable handle, appealing design, and installing a small mirror that folds open on the back of the handle; we believe this would be quite appealing to our potential buyers.

1.0 Introduction

Our group was tasked with redesigning an electric toothbrush to make it more sustainable and pleasing to the customer. Through market analysis, product archaeology, and benchmarking, we plan to make a better all-around toothbrush that appeals to a large part of the market. We hope that our toothbrush will leave our customers with not only a cleaner mouth, but also a better, more convenient overall brushing experience. In our personal research, we have taken a toothbrush apart to understand its assembly and analyzed each of the parts, which gives us a good idea of how the whole product works. Our market analysis consisted of a customer survey and us identifying our most aspects of the toothbrush to figure out the main problem areas and turn them into strong points.

1.1 Initial Problem Statement

As a team, we were given an electric toothbrush to analyse and disassemble it to get a better understanding of the design of the toothbrush. As a part of our redesign process, we are to complete external searches on existing products on the market in order to develop a toothbrush that is more sustainable. After this, we are to develop our own toothbrush design based off of the strengths and weaknesses of our starting toothbrush. We will use our knowledge of our toothbrush and new design to better engineer and toothbrush with better efficiency and sustainability.

2.0 Customer Needs Assessment

In an effort to fully understand our consumers' needs, we surveyed 12 people at random about various questions concerning their dental hygiene and toothbrushes. The survey's questions were based upon crucial customer needs that we listed below. After reviewing our survey results, we were able to narrow our list down using a PCC chart and AHP chart.

The feedback we received indicated that a rechargeable toothbrush would be the best option and that aesthetics do matter to our customers. We also decided to add in some new technology to our toothbrush, such as a mirror attached to the back of the toothbrush, a tongue cleaner on the back of the brush head, a dual-opposite rotation head. All of these details add up together to make a unique toothbrush that has not been seen yet.

2.1 Weighting of Customer Needs

Initial Customer Needs List

1. Appearance
2. Ease of use (on/off switch)
3. Cleaning of brush
4. Power supply (batteries or rechargeable)
5. Durability of brush
6. Cleaning ability of brush
7. Professional recommendations
8. Technology
9. Cost
10. Size of grip

The PCC chart displays our comparisons with the various customer needs stated above. Rather than comparing every factor together at once, the PCC chart allowed us to compare them individually. After doing all the comparisons, we totaled up the point values to determine the most important customer needs.

PCC Chart

	1	2	3	4	5	6	7	8	9	10	Total
1	X	-1	+1	+1	-1	-1	+1	+1	-1	+1	1
2	+1	X	+1	+1	-1	-1	+1	+1	-1	+1	5
3	-1	-1	X	+1	-1	-1	+1	+1	-1	+1	-1
4	-1	-1	-1	X	-1	-1	+1	+1	-1	+1	-3
5	+1	-1	+1	+1	X	-1	+1	+1	-1	+1	3
6	+1	+1	+1	+1	+1	X	+1	+1	+1	+1	9
7	-1	-1	-1	-1	-1	-1	X	-1	-1	+1	-7
8	-1	-1	-1	-1	-1	-1	+1	X	-1	+1	-5
9	+1	+1	+1	+1	+1	-1	+1	+1	X	+1	7
10	-1	-1	-1	-1	-1	-1	-1	-1	-1	X	-9

AHP Chart

Customer Need #	1	5	6	7	8	9	Total	Weighting
1	1	1/6	1/8	1/2	4	1/9	5.903	.068
5	6	1	1/2	6	7	1/2	21	.242
6	8	2	1	5	8	1/3	24.333	.281
7	2	1/6	1/5	1	5	1/6	8.533	.098
8	1/4	1/7	1/8	1/5	1	1/4	1.968	.023
9	9	2	3	6	4	1	25	.029

The AHP chart we composed above displays what we considered to be most important by weighting out the factors. Based on our chart, we have come up with a hierarchical list of customer needs.

Hierarchal List of Customer Needs

1. Cost
2. Cleaning ability of brush
3. Durability of brush
4. Professional recommendation
5. Appearance
6. Technology

3.0 Revised Problem Statement

Our assessment of our original toothbrush told us that we needed a more sustainable battery along with new brush heads and we wanted to make it more aesthetically pleasing. Most of these characteristics can be accomplished through a new design of the toothbrush. Our problem now will be to construct a better and more efficient toothbrush based on our assessment and redesign process.

4.0 External Search

As part of our design project, we performed two labs to better understand our toothbrush. Also, we conducted a patent search and we benchmarked our toothbrush against other products on the market.

4.1 Lab 1 and Lab 2 Reports

We performed labs using our toothbrush that we were given. Lab 1 constituted noise measurements and power analysis. We measured the noise level of the toothbrush to get a better understanding of the noise that the toothbrush creates. After, we measured the power generated by the batteries and the voltage required to power the motor. By completing these measurements, we could understand the power required for the toothbrush and take these calculations under consideration when redesign our toothbrush.

Lab 2 involved product dissection to view the inside parts of the original toothbrush. In order to do this, we used standard tools, including pliers and a saw, to “break open” the toothbrush. Once we started to separate the individual parts, we completed a bill of materials, which included size, cost, dimensions, and other qualities of each individual part. After completing the bill of materials, we had separate parts categorized so that we could see their value to the toothbrush. Both labs that were completed assisted us in our redesign process by analyzing the original toothbrush and its individual components.

4.2 Patent Search

As part of our external search, we conducted a patent search to look at the technologies used in the electric toothbrush. This will focus on utility patents to summarize other products that are similar to our toothbrush.

Function			Art	
	Electric Cautery	Electric switches	Moving magnet, rotary switch	Removable head mechanism
Dental Cleaning Device	US7979939			US4827550
Safety shield control device		US4349814		
Variable torque motor			US4580062	

4.3 Product Archaeology

The number of bristles has increases over the years:

2002

2006

2009-Present

Method of brushing has developed over the years:

Manual

Vibrating-Head

Oscillating Head

4.4. Benchmarking

Feature	Oral B	Crest Spin Brush	Colgate	Reach
Packaging	3	3	3	3
Aesthetics	2	4	3	2
Convenience of on/off switch	5	5	5	5
Ease of clean	4	3	4	2
Durability of brush head	2	1	3	3
Size of grip	4	4	3	3
Ability to clean brush head	4	5	4	4
Battery life	4	2	3	3

Based on our benchmarking techniques, we have concluded that all four toothbrushes have their own strengths and weaknesses. Each one was designed specifically to satisfy a certain need very well while lacking in other categories. Overall, the best toothbrush would be the one that could best satisfy the needs of the customer based on their preferences.

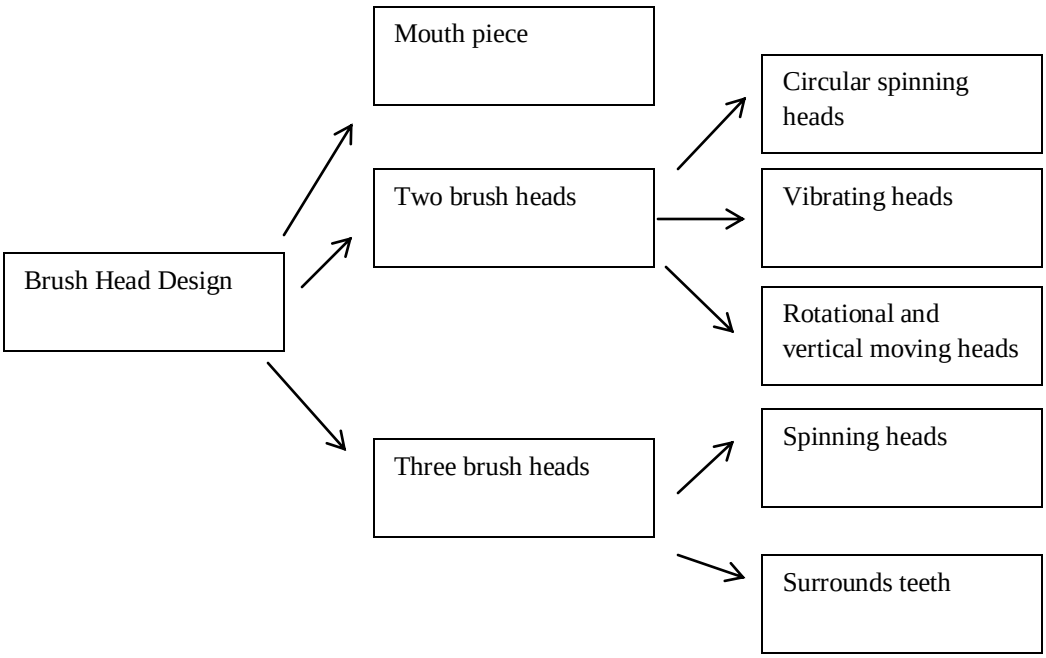
4.5 Design Target

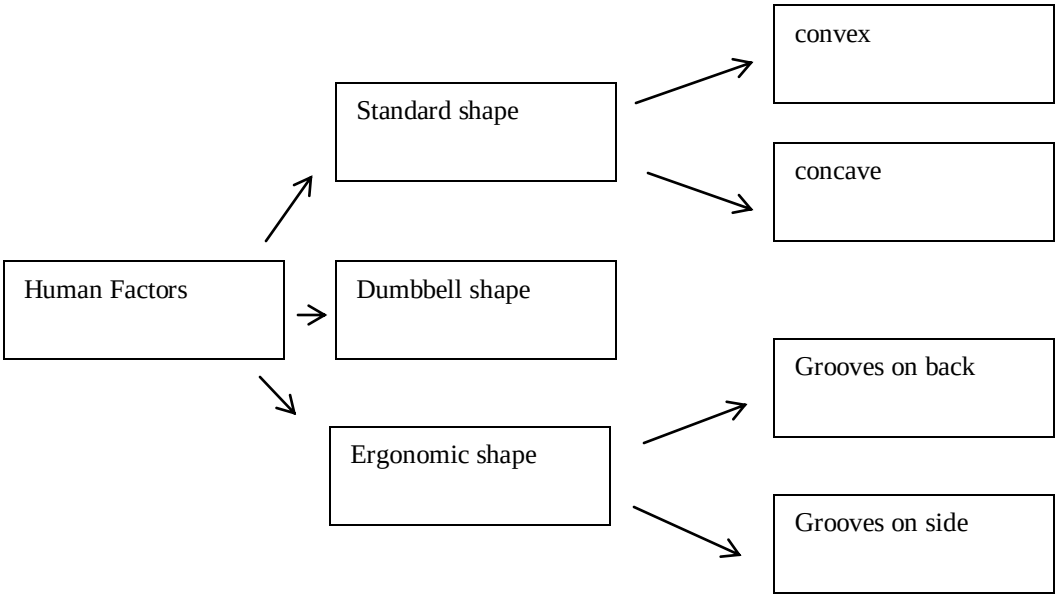
Based off of our entire external search process, we determined that the best toothbrush design is one that appeals to our customers and utilizes our findings from our research. We believe the best toothbrush is one that uses sustainable energy and is aesthetically pleasing. However, the chief concern is a toothbrush that is low cost so it is available to all people.

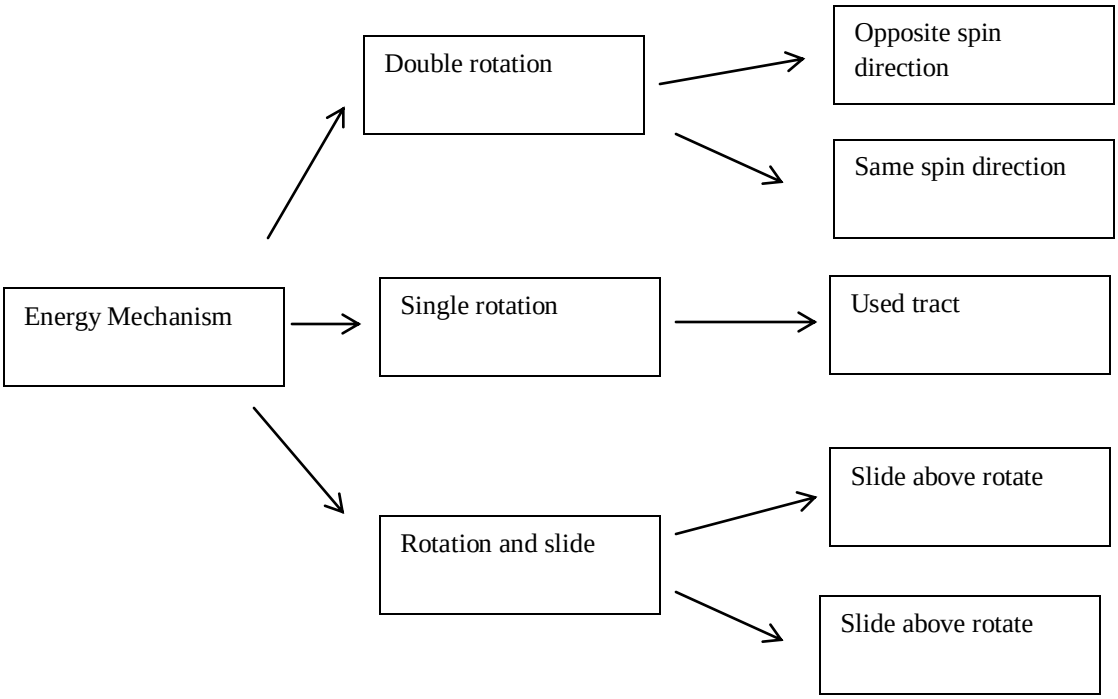
5.0 Concept Generation

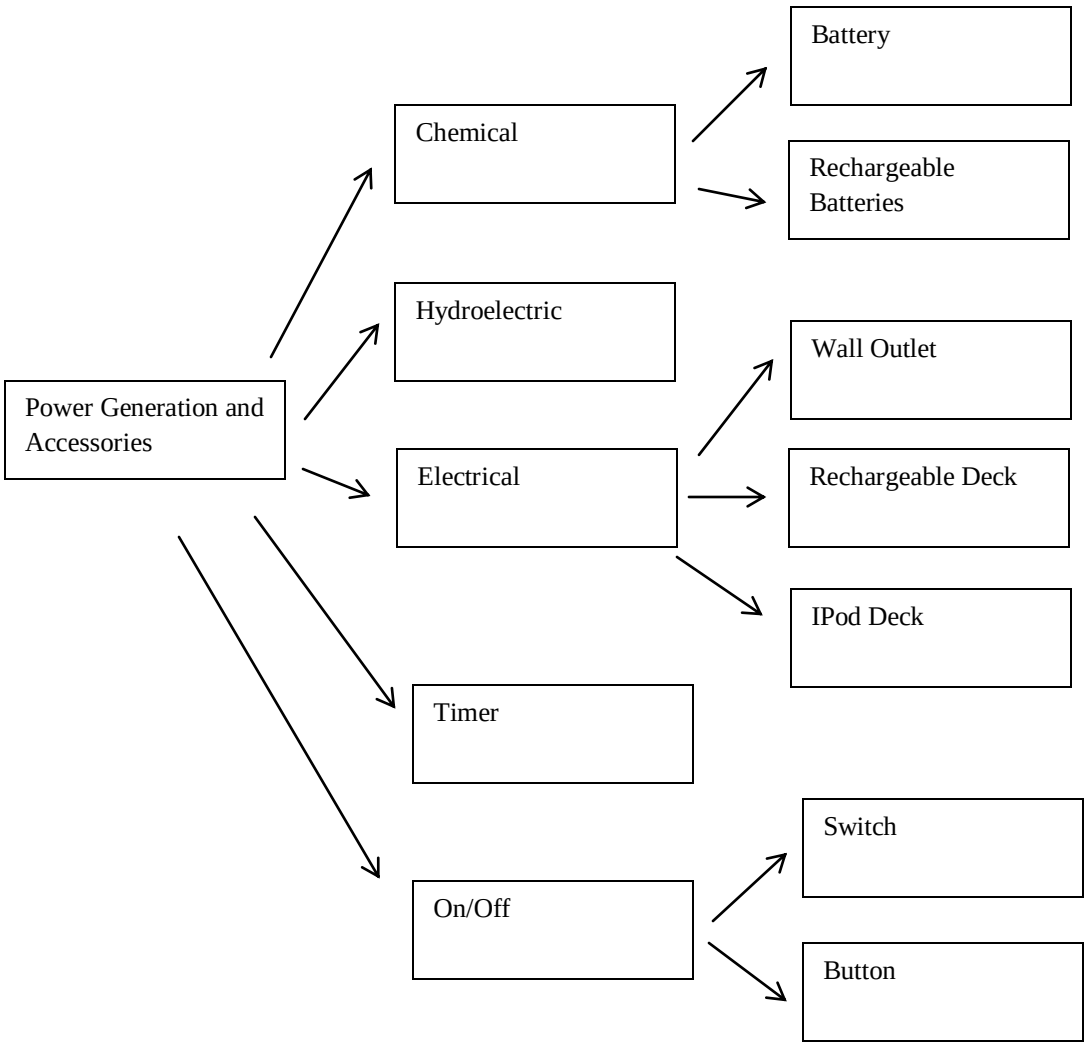
5.2 Concept Generation

After thorough external searches, we took a closer look at our original toothbrush to begin to develop preliminary concepts that we could use for our redesign. Taking into account our customer needs, benchmarking results, and other external searches, we came up with concepts for our redesigned toothbrush. Here our concept classification trees for brush head design, human factors, energy mechanism, and power generation and accessories.



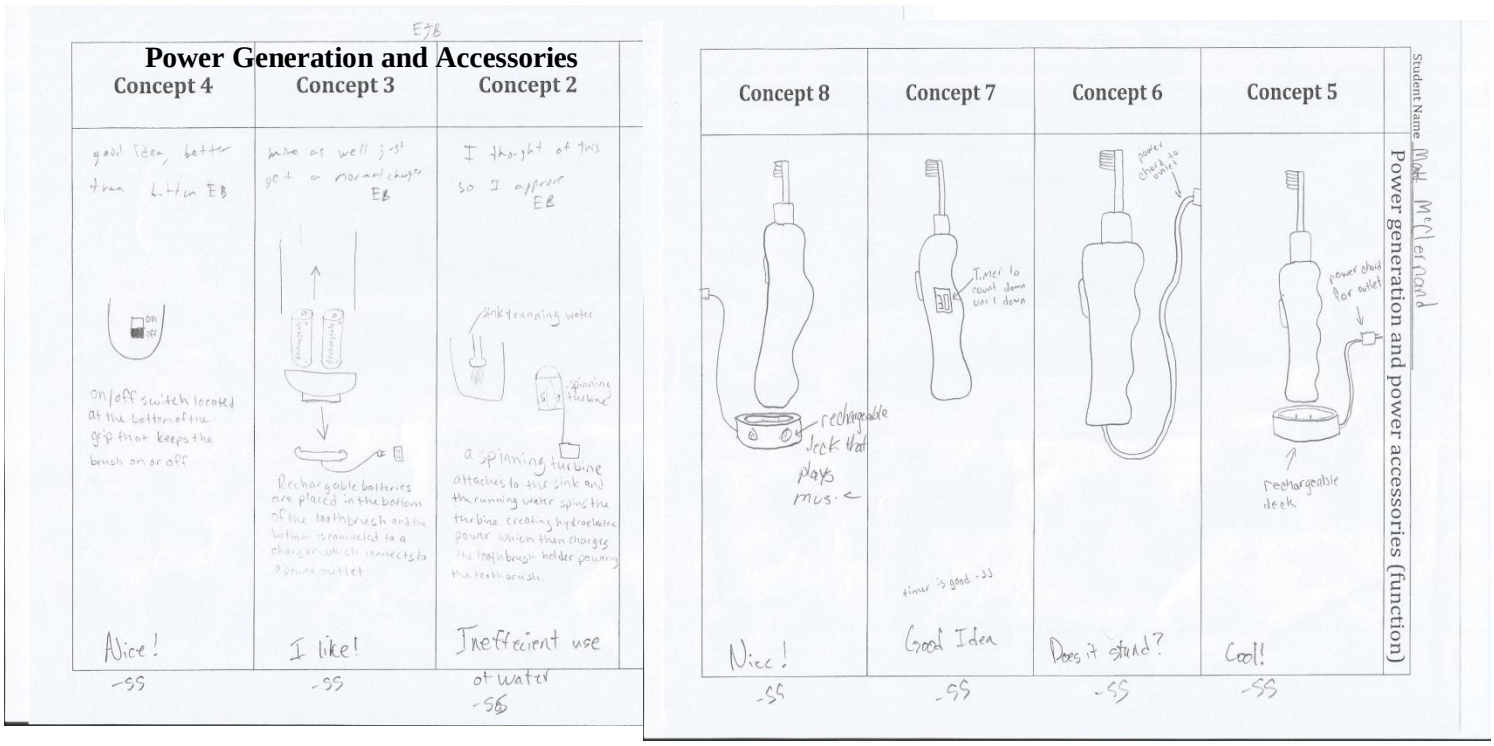



Energy Mechanism
Double rotation
Opposite spin direction
Same spin direction
Single rotation
Used tract
Rotation and slide
Slide above rotate
Slide above rotate

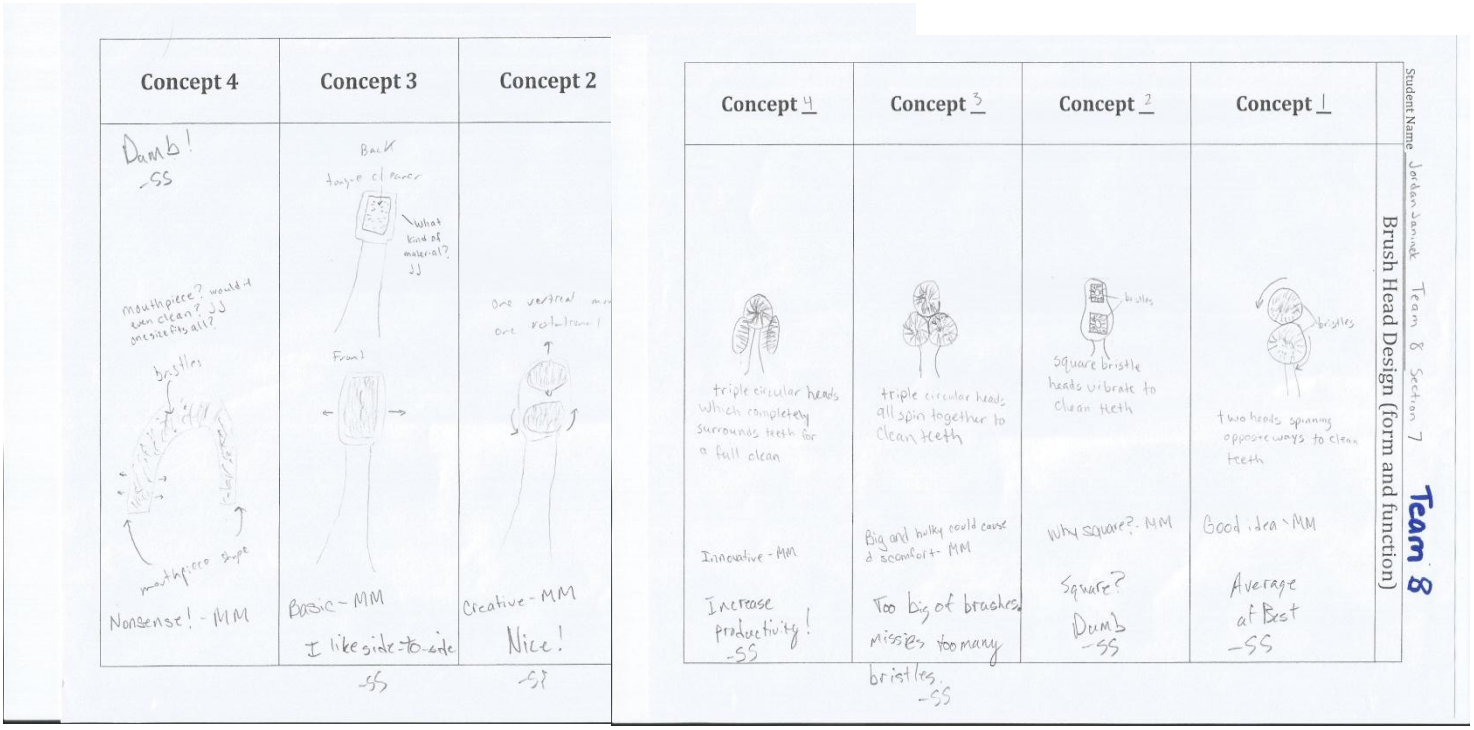

Power Generation and Accessories
Chemical
Battery
Rechargeable Batteries
Hydroelectric
Electrical
Wall Outlet
Rechargeable Deck
IPod Deck
Timer
On/Off
Switch
Button

Sketches of Generated Topics

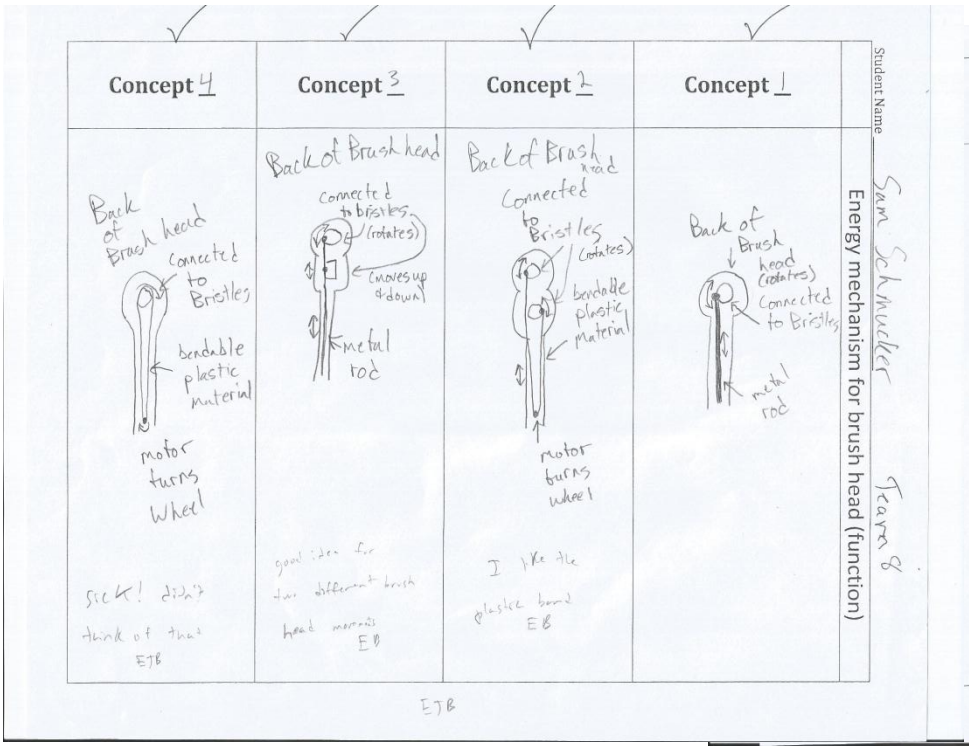
Listed below are sketches of concepts that we drew so that we could see all of our concepts. Each one is separated by topic. From here we could narrow down our choices to pick the best one.

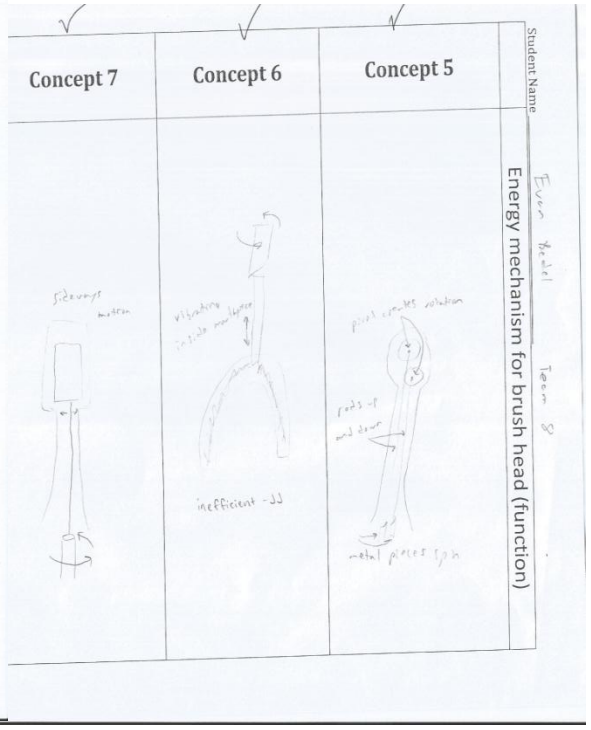


Brush Head Design

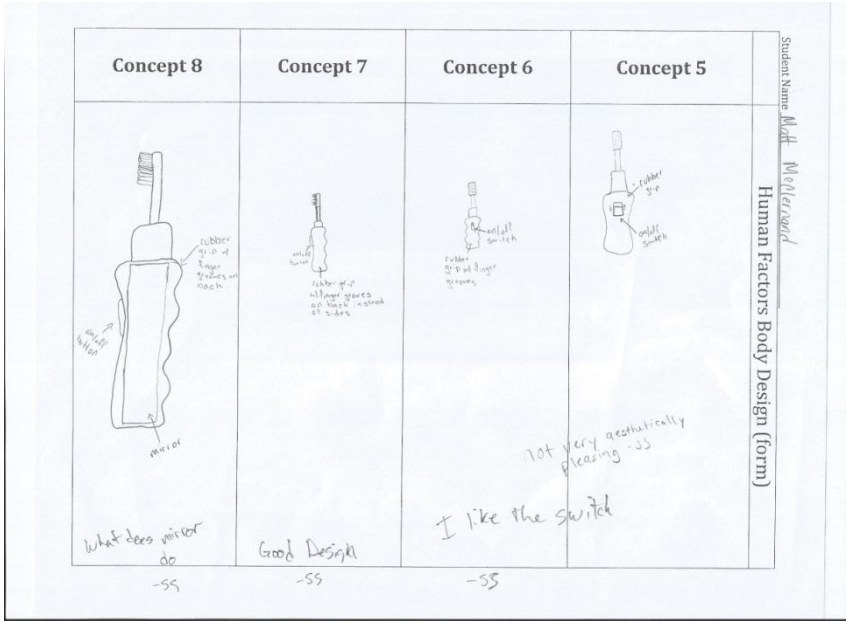


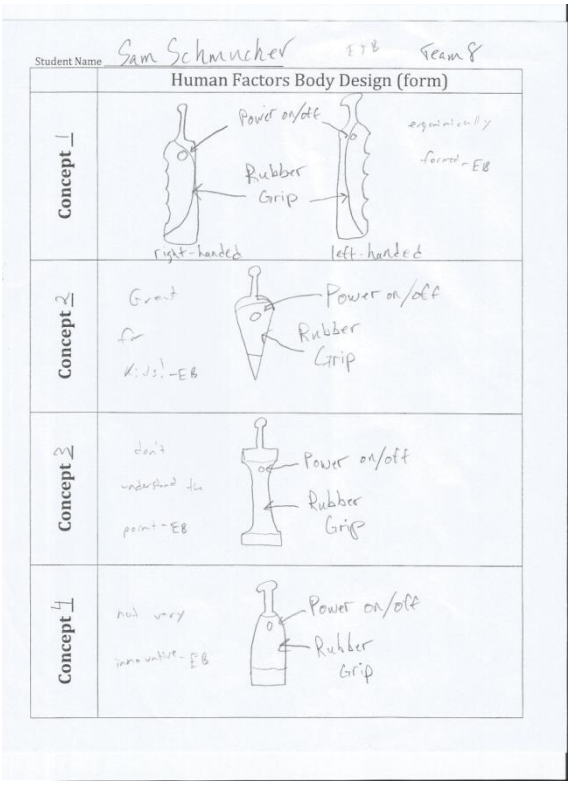
Energy Mechanism





Human Factors





After establishing preliminary concepts using concept trees and sketches, we then had to narrow down our concepts in order to pick the best one. We did this by using a morphological chart and Pugh charts that are listed below.

Morphological Chart

The morphological chart displays our final three or four concepts that we will make a decision from.

Power Generation & Accessories	**Brush Head Design**	**Energy Mechanism**	**Human Factors Body Design**
Batteries	2 circular spinning heads	Opposite spin direction	Dumbbell shape
Rechargeable Batteries	One spinning head and one vertical movement head	Used tracts	Convex
Rechargeable Deck	3 circular heads that surrounds head	Rubber bands	Grooves on back
		Rotate above, slide	

Pugh Charts

Pugh charts are used to analyze our concepts that are generated and weigh them based on our customer needs. This is important because we must compare each concept to each other and analyze which one best meets our customer needs.

Human Factors	**Size**	**Cost**	**Weight**	**Comfort**	Total	Rank
Weighting	0.15	0.4	0.2	0.25		
Concepts						
Iteration 1						
dumbbell	0	0	0	0	0	2
convex	1	1	-1	-1	0.1	1
grooves	1	-1	-1	1	-0.2	3
Iteration 2						
dumbbell	-1	-1	1	1	-0.1	2
convex	0	0	0	0	0	1
grooves	1	-1	-1	1	-0.2	3

Brush Head	**Size**	**Cost**	**Comfort**	**Power**	Total	Rank
Weighting	0.15	0.4	0.2	0.25		
Concepts						
Iteration 1						
Circular Spinning heads	0	0	0	0	0	1
one up one down	-1	-1	-1	-1	-1	2
3 surrounding	-1	-1	-1	-1	-1	2
Iteration 2						
Circular Spinning heads	1	1	1	1	1	1
one up one down	0	0	0	0	0	2
3 surrounding	-1	-1	1	-1	-0.6	3

Power Generation	**Size**	**Cost**	**Weight**	**Power**	Total	Rank
Weighting	0.15	0.4	0.2	0.25		
Concepts						
Iteration 1						
batteries	0	0	0	0	0	2
rechargeable batteries	0	-1	-1	-1	-0.85	3
rechargeable deck	-1	1	1	1	0.7	1
Iteration 2						
batteries	0	1	1	1	0.85	1
rechargeable batteries	0	0	0	0	0	3
rechargeable deck	-1	1	1	1	0.7	2
Iteration 3						
batteries	1	-1	-1	-1	-0.7	2
rechargeable batteries	1	-1	-1	-1	-0.7	2
rechargeable deck	0	0	0	0	0	1

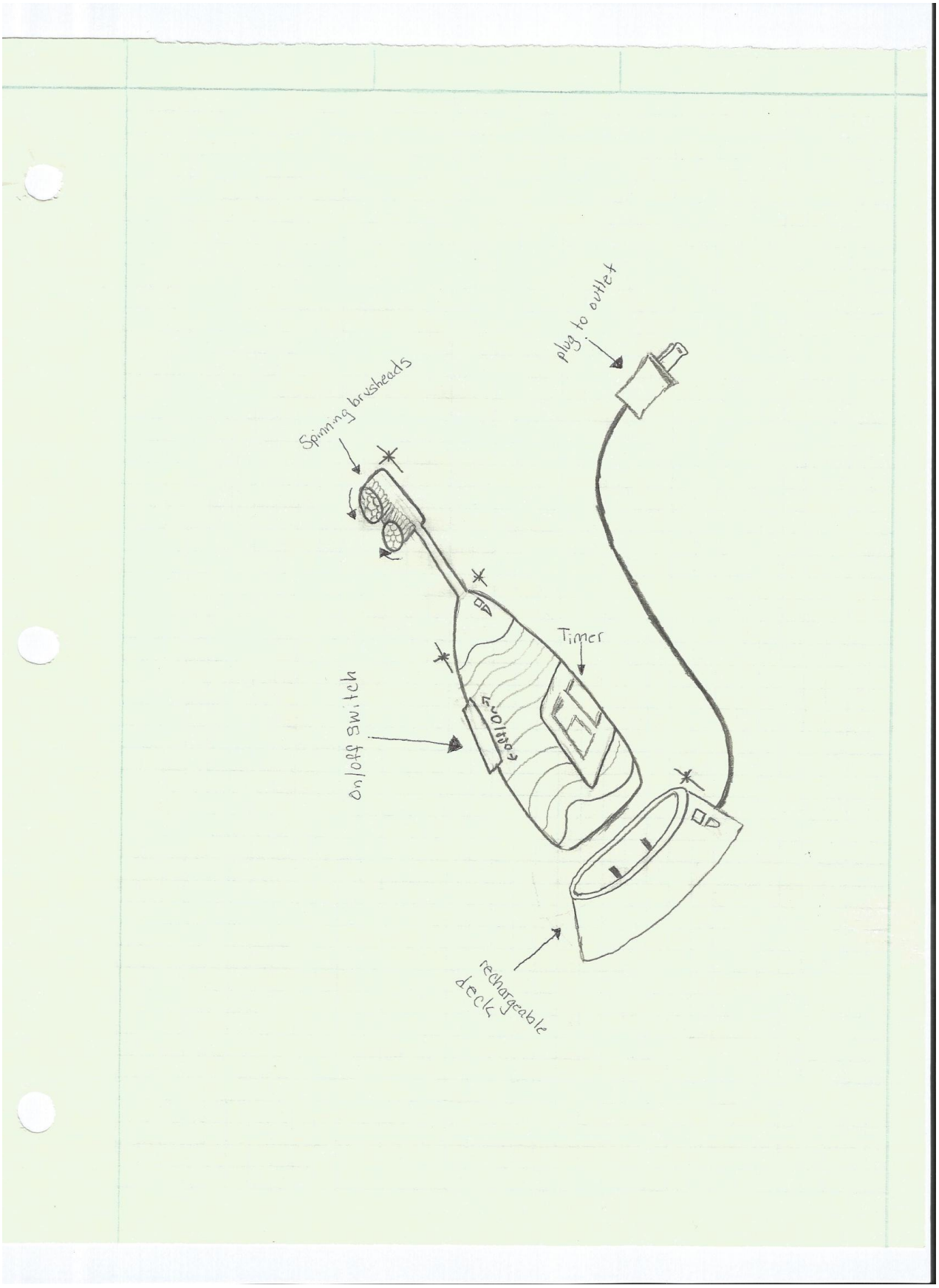
Energy Mechanism	**Size**	**Cost**	**Weight**	**Power**	Total	Rank
Weighting	0.15	0.4	0.2	0.25		
Concepts						
Iteration 1						
Opposite spin direction	0	0	0	0	0	2
Used tracts	-1	-1	-1	-1	-1	4
rubber bands	1	1	1	-1	0.5	1
Rotate above, slide	1	-1	1	-1	-0.6	3
Iteration 2						
Opposite spin direction	1	1	1	1	1	1
Used tracts	0	0	0	0	0	3
rubber bands	1	1	1	-1	0.5	2
Rotate above, slide	-1	-1	-1	1	-0.5	4
Iteration 3						
Opposite spin direction	-1	-1	-1	1	-0.5	2
Used tracts	-1	-1	-1	1	-0.5	2
rubber bands	0	0	0	0	0	1
Rotate above, slide	-1	-1	1	-1	-0.6	4

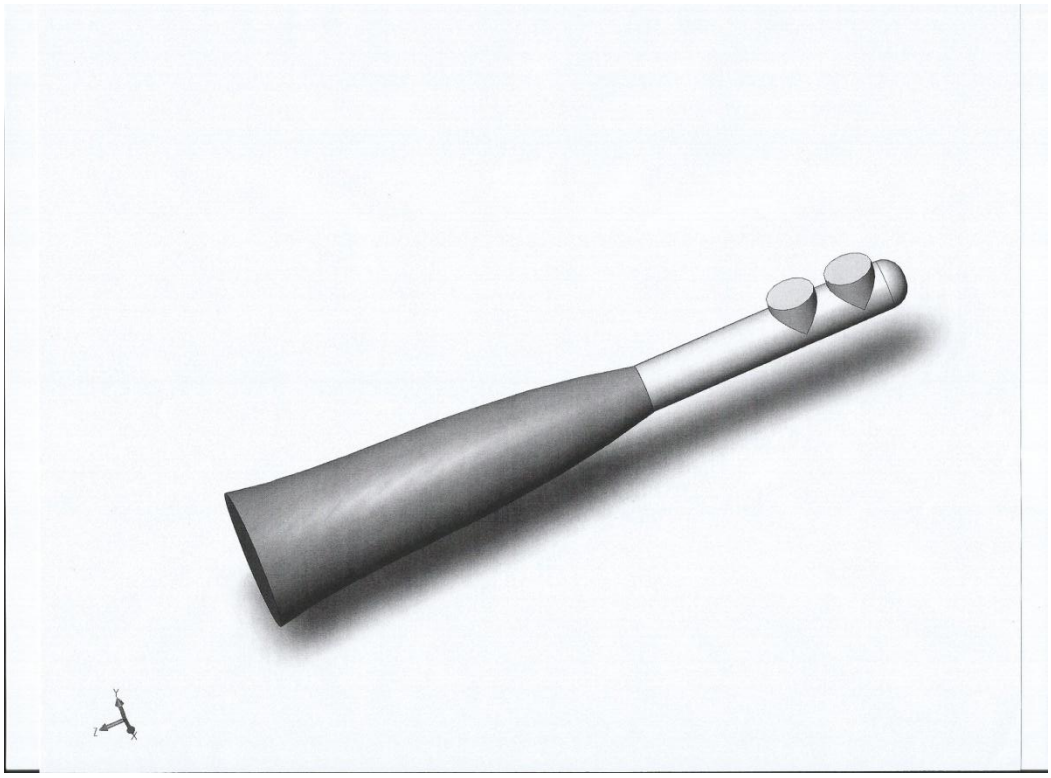
From our Pugh charts, we have determined our best concepts that meet our customer needs. For our human factors design, we feel that a convex shape for the handle will be the best for the customer. The brush head that is the most efficient for our design is two circular opposite spinning heads. The most sustainable power generation method is a rechargeable deck that recharges the toothbrush after use. Lastly, the most effect energy mechanism for our toothbrush is two ribbed rubber bands attached to a motor that will spin the brush heads.

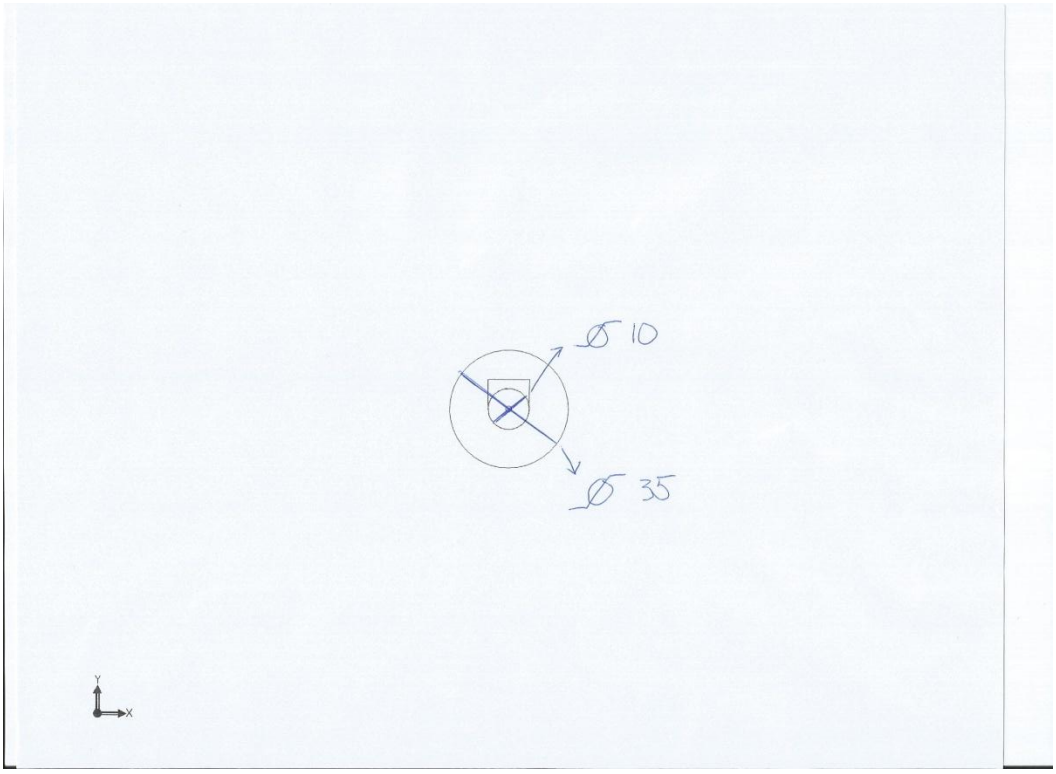
6.0 Final Design

The final design of the toothbrush is very similar to the original because we realized that the most efficient and least costly design would be the one the company is already using. We asked ourselves, “Why mess with a winning formula?” However, we did make a few upgrades that our customers seemed to be concerned with. The main upgrade of the new toothbrush was the entire brush head. We changed the brush bristles from one singular rotating head to two heads that rotate in opposite directions. Also, we changed the energy mechanism from a spring loaded metal rod to a rubber band that rotates about a gear from the motor and gears on the back of the brush heads. On top of that, we decided it was best for the customer to have a rechargeable docking station for the toothbrush rather than having normal batteries which would needed to be replaced, which continually brings cost up. While leaving the same body, we gave it a facelift by adding new features, such as a timer to let you know when it is time to stop brushing and we changed the on/off button to a switch because the button seemed to get caught easily and was not user friendly.

6.1 Design Drawings, Parts List and Bill of Materials



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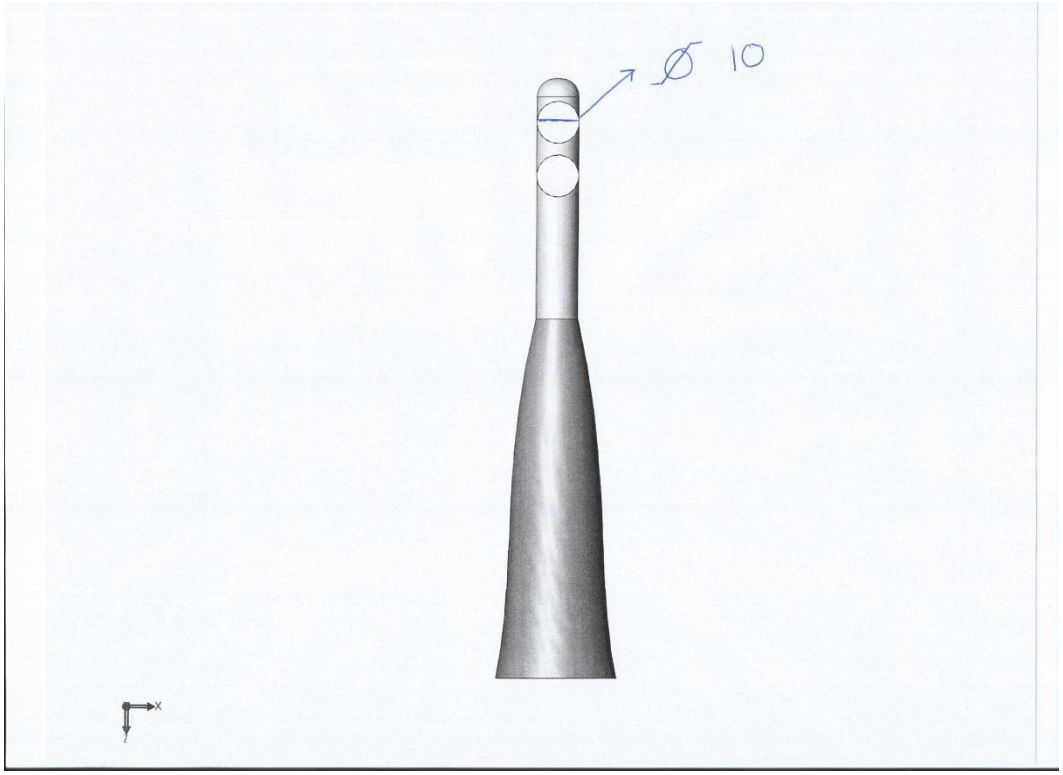
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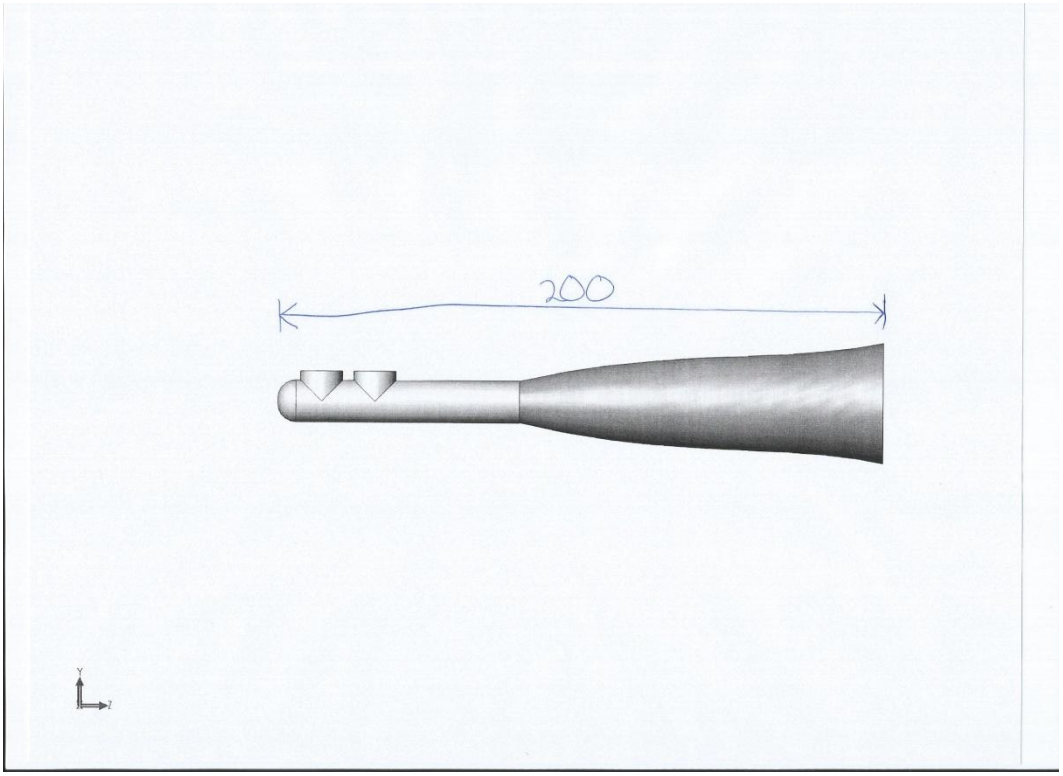
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Parts List

1. Outer case
2. Brush head
3. Rechargeable dock
4. Rubber bands
5. Motor
6. Motor case

Bill of Materials

	Quantity	SOP effect	Function	Material	Cost
Outer case	1	No	Holds inner workings of toothbrush	Hard plastic and LED screen	$1.00
Brush head	2	No	Cleans teeth	Plastic with nylon bristles	$.80
Rechargeable dock	1	Yes	Charges motor	Hard plastic	$1.75
Rubber band	1	No	Transfers energy from motor to brush heads	Flexible rubber	$.20
Motor	1	Yes	Powers toothbrush	Metal	$.70
Motor case	1	No	Holds motor	Plastic	$.30

Implanted in the outer case will be a LED screen showing a countdown from two minutes to let the consumer know how long they have been brushing their teeth. The screen will be of size 30 mm x 20 mm and will be located midway through the handle of the toothbrush. The on/off switch will be on the opposite side of the toothbrush located one third of the way down from the top of the handle of the toothbrush for ease of the customer.

6.2 How does it work?

The power generation for our toothbrush begins with the charging deck. This deck plugs into an electrical outlet to charge the rechargeable battery, which in turn holds its charge until the next usage. After the battery in the toothbrush has received a full charge, the deck has a switch that stops pulling power from the wall outlet to conserve energy. The electric motor is then powered by this battery, causing the motor to spin horizontally. This horizontal spin is transferred into a vertical spin by a small gear, which in turn is connected to the two separate bands that spin the brush heads. Both bands have are connected to the gear oppositely so that they spin opposite one another. The heads both have pivot points so that the bands can spin all the way around while the heads spin at the same rate. The gives the opposite spinning heads for optimal cleaning ability.

7.0 Conclusion

In redesigning our toothbrush, reducing cost while still maintaining an innovative toothbrush was a crucial goal we feel we successfully achieved. We found that consumers are more intrigued with a toothbrush that has a rechargeable deck rather than one requiring batteries because it is convenient and cheaper in the long run. For the energy mechanism, we replaced the metal rod inside the toothbrush with a durable rubber band which not only cost less to manufacture but also provides the brush heads with a smoother rotation. The opposite spinning dual brush heads plus the timer aids the user in achieving a sufficient clean. Lastly, the convex handle, smooth grip, and on/off switch further benefit the aesthetics of the brush. These factors all appeal to potential customers of all ages. We are extremely confident that the Champion Toothbrush will be very popular in the marketplace and compete extremely well with the current leading electric toothbrushes.

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Appendix

2.3 Survey Questions

1. How much would you be willing to pay for an electric toothbrush that does its job successfully?
   A. Under $10
   B. $10-$25
   C. $25 and up
2. Does the noise level of an electric toothbrush matter to you?
   A. No, noise doesn't matter
   B. Bearable, as long as it works
   C. Yes, noise matters
3. How big do you prefer the toothbrush head to be?
   A. Small
   B. Medium
   C. Large
4. How many times do you brush your teeth in one day?
   A. 1
   B. 2
   C. 3 and up
5. How often do you change your toothbrush?
   A. Once a month
   B. Once every two months
   C. 3 months and up
6. Does color matter to you?
   A. Yes
   B. No
   C. Depends on the color
7. Do you prefer:
   A. Manual
   B. Battery powered
   C. Rechargeable
8. Do you want your toothbrush to be professionally recommended?
   A. Yes
   B. No
9. On average how long do you brush your teeth?
   A. Under a minute
   B. 1-2 minutes
   C. 2+ minutes
10. Do you have a history of cavities?

A. Yes
B. No

11. How often do you go to the dentist?
    A. Once a year
    B. Twice a year
    C. More than twice a year
12. Do you travel with your daily toothbrush?
    A. Yes
    B. No

4.1 Lab 1 & Lab 2 Reports

These labs helped us get a better look at all of the component parts of our toothbrush.

DATA SHEET 2

1. Noise Measurement:

Location:	**Noise level: dB**
Brush head 4 in away from decibel meter	65.3
Brush head 3 in away from the decibel meter	66.5
Brush head 2 in away from decibel meter	67.4
Brush head 1 in away from the decibel meter	71.3
DC motor 4 in away from decibel meter	68.2
DC motor 3 in away from the decibel meter	69.1
DC motor 2 in away from the decibel meter	72.4
DC motor 1 in away from the decibel meter	73.3

Approximate duration of brushing per day: 2 minutes/day
Average noise level during brushing: 69.175 dB on average

2. Power Measurement:

Voltage supplied to the circuit:

Battery Type	**Volts (V):**	
Battery 1	AA	1.505
Battery 2	AA	1.511

Total Voltage:

Connection Type	**Volts (V):**	
Battery 1 and Battery 2	Series	3.016

Current Measurements	**Averaged Current Value**
No load condition	.3 amps

Load condition(s)

1.	.75 amps
2.	.6 amps
3.	.42 amps
4.	.98 amps

Mean current 'under load' .6875 amps

Voltage Current					
Power (no load) =	3.016	X	.3	= .9048	Watts
Voltage Current					
Power (under load) =	3.016	X	.6875	= 2.0735	Watts

Visuals: Component pictures, sketches and/or solid models <u>(place team members name who completed each visual)</u>	
Jordan	Evan
Sam	Matt

Jordan	Matt

Bill of Materials

Product Manufacturer/Model Number: Oral-B 4739

Date: 9/17/12

Disassembly method:
Subtract and Operate Procedure (SOP): Yes, No. **Force (Energy) Flow Diagram: Yes, No.**

Team leader name(s)	Part#	Part Name	QTY	SOP Effect	Function	Mass (oz, g)	Material	Manuf. Process	Dimensions (cm)	Cost	Time to Complete Part Dissection (minutes)
	1	Outer case	1	No	Holds battery and motor	20.87 g	Hard plastic	Injection molding	14.5 x 2.8 x 2.4	$.65	18
	2	Battery	2	Yes	Powers motor	24.49 g	Alkaline	Purchased component	1.4 x 5 x 1.4	$1	1/6
	3	Motor	1	Yes	Powers brush head	39.92 g	Metal	Purchased component	16.5 x 1.9 x 1.5	$.75	9
	4	Motor case	1	No	Contained motor	9.98 g	Plastic	Injection molding	11.5 x 2.7 x 2.4	$.25	9

	5	**Brush head**	**1**	**No**	**Cleaned teeth**	**5.44 g**	**Plastic with nylon bristles**	**Plastic – Injection molding Nylon – Extruded Epoxy/Glue – attach bristles**	**1.3 x 1.3 x 1.8**	**$.55**	**1**
	6	**Brush head cover**	**1**	**Yes**	**Protected brush when not in use**	**2.72 g**	**Clear plastic**	**Injection molding**	**5.9 x 1.3 x 1.7**	**$.10**	**1/30**
	7	**Shaft**	**1**	**No**	**Connects motor to brush head**	**.91 g**	**Plastic and metal**	**Powdered injection molding**	**4.5 x .4 x .4**	**$.15**	**26**
	8	**Battery cover**	**1**	**No**	**Keeps batteries within toothbrush and closes circuit**	**5.44 g**	**Plastic and metal**	**Injection molding and purchased component**	**3.6 x 2.6 x 2.3**	**$.20**	**1/15**

	9	O-ring	1	No	Tightens fit of battery cover and seals water out	.3 g	Rubber	Purchased component	20	$.02	1/30