PROJECT 1 FINAL REPORT

Randall Gough
Kelci Knepp
Matt DiSanto
Nick Hedge

10/15/12

Team 1

Abstract

Our objective is to design an electric toothbrush that better fits customer needs. We surveyed 14 people to better understand the customer demand. From the surveys, we concluded that many people did not use electric toothbrushes because of the cost. One of our main goals will be to keep our toothbrush at a relatively low cost. The second most important factor to our customers was the comfort and grip of the toothbrush. Noise level was another important factor we noticed from our surveys. Many of the survey takers also said they would pay more for a rechargeable toothbrush. Other changes such as appearance and portability were not a great concern to our customers. Because of this we will make few changes to these characteristics. The main changes we will make to our toothbrush will be the grip and making it rechargeable. We will also try to keep this as inexpensive and noise free as possible.

1.0 Introduction

Our project is to redesign an electric toothbrush to better meet our customers' needs. We were given an electric toothbrush to disassemble and analyze so that we could better design our toothbrush. We then created a customer needs list and used a Pairwise Comparison Chart (PCC) and the Analytic Hierarchy Process (AHP) to rank our customer needs in importance. Our group next developed a customer survey which we could use to find what consumers were looking for and how much they would pay for the toothbrush. We then did an external search for information about our product, patents relevant to our project, product history, and information about other similar products on the market.

1.1 Initial Problem Statement

Our task is to compare and analyze the demand in the market for sustainable toothbrushes. We will modify an existing electric toothbrush and design an electric toothbrush that will better meet the needs of customers.

2.0 Customer Needs Assessment

A survey was created in order to better understand customer needs. This survey was given to 14 different people. Based upon the results of this survey an AHP chart was created of the customer needs. The AHP chart is based upon weighted values. This is important because it shows the importance of the features relative to each other. Without this weighting it seems that the hierarchal customer needs would be much harder to decipher.

2.1 Weighting of Customer Needs

Table 1. Initial Customer Needs List Obtained from Team Focus Group and Individual Surveys

A-Timer
B-Appearance/ colour
C-Different speeds/modes
D-Power source
E-Ambidextrous use
F-Portability
G-Comfort
H-Cost
I-Sustainability
J-Durability/Strength
K-Size of the motor
L-Weight of toothbrush
M-Size of brush head

	A	B	C	D	E	F	G	H	I	J	K	L	M	Total
A	X	1	0	-1	1	-1	1	-1	1	-1	-1	1	-1	-1
B	-1	X	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-12
C	0	1	X	-1	1	-1	1	0	1	-1	1	0	1	3
D	1	1	1	X	1	0	1	0	1	0	-1	-1	-1	4
E	-1	1	-1	-1	X	-1	0	-1	-1	-1	-1	-1	-1	-9
F	1	1	1	0	-1	X	1	0	0	-1	0	0	-1	1
G	-1	1	-1	-1	0	-1	X	0	0	-1	-1	0	-1	-6
H	1	1	0	0	-1	0	0	X	1	-1	0	0	1	2
I	-1	1	-1	-1	-1	0	0	1	X	-1	-1	0	-1	-5
J	1	1	1	0	-1	1	1	-1	1	X	1	1	1	7
K	1	1	-1	1	-1	0	1	0	1	-1	X	0	-1	1
L	-1	1	0	0	-1	0	0	0	0	-1	0	X	-1	-3
M	1	1	-1	-1	-1	1	1	-1	1	-1	1	1	X	2

Figure 1. Initial Customer Needs PCC Chart

Figure 1 is a PCC chart of the potential needs a customer would want in an electric toothbrush. The PCC chart is a ranking system in which each customer need is compared in importance against all of the other customer needs. As a team we completed this chart. From the results we eliminated certain customer needs that ranked low on the PCC chart. This is how Table 2 was assembled. Table 2 is the top 7 rankings of customer needs that we found to be important the PCC chart.

Table 2. Weighted Hierarchal Customer Needs List

1. Durability
2. Power source
3. Different speeds
4. Cost
5. Comfort
6. Portability
7. Timer

	Durability	Power Source	Different Speeds	Cost	Comfort	Portability	Timer	Total	%
Durability	1	3	5	5	7	5	7	33	31.9
Power Source	0.333	1	5	3	7	5	7	28.333	27.4
Different Speeds	0.2	0.2	1	3	5	3	1	13.4	12.9
Cost	0.2	0.333	0.333	1	1	0.333	0.333	3.53	3.4
Comfort	0.143	0.143	0.2	1	1	0.2	1	3.69	3.5
Portability	0.2	0.2	0.333	3	5	1	5	14.73	14.2
Timer	0.143	0.143	1	3	1	0.2	1	6.49	6.3
								103.173	

Figure 2. AHP Pairwise Comparison Chart to Determine Weighting for Main Objective Categories

Table 3. Weighted Hierarchal Customer Needs

1. Durability (0.319)
2. Power Source (0.274)
3. Different Speeds (0.129)
4. Cost (0.034)
5. Comfort (.035)
6. Portability (.142)
7. Timer (.063)

3.0 Revised Problem Statement

According to our surveys, the sustainability of an electric toothbrush was not a huge factor in the reason people don't use electric toothbrushes. Customers were more concerned with the cost, grip, the ability to recharge, and noise of the toothbrush. We will now work on creating a toothbrush that addresses these factors instead.

4.0 External Search

To better understand the features of the electric toothbrush, there was researching that needed to be done outside of the actual experiment. This helped us to better understand other models and brands of toothbrushes besides the one we were supplied with.

4.1 Lab 1 & Lab 2 Reports

Through our first and second lab reports, we learned and observed many important factors and functions of our toothbrush. We observed that not only could we fix the toothbrush in many ways but also the packaging. The packaging may display the product very well, but the material it is made from is not the most environmentally friendly and is difficult to open. At physical and first looks we thought that the toothbrush we were using was very well done, and not many improvements could be made. But after first glance and testing we thought that we could make the toothbrush lighter, while at the same time providing a power source that is rechargeable. Lab 1 of this project was used to find general and background information about the toothbrush we were to do the project on. In Lab 2 the battery life of the toothbrush was found and also the number of volts required to power the toothbrush. We were able to use these results to find that our design of a series of three lithium watch batteries would be enough to power an electric toothbrush. The toothbrush was dissected and each part was labelled and analyzed in this lab also. This helped us to take a closer look at each individual part, internal and external, that made up the electric toothbrush. In our design we improved upon some of these elements to make a toothbrush model that is better designed for customers. Both of these labs and the data can be found in the Appendix at the end of the report.

4.2 Patent Search

In the following table we have listed patents relevant to our project. We searched through the Google patent database for any patents relevant to electric toothbrushes. We then went through the list of patents selecting ones that had a technology we wanted to include in our toothbrush, such as a replaceable head, or ways to make the brush head oscillate, rotate or vibrate.

Table 4. Patent Search for Electric Toothbrushes

FUNCTION			**ART**		
	Pressure over time	Bristles, drive pin, bearing pin, replaceable	Switch	Detachable head	Battery
Timer	US 4450599				
Brush head		US 5867856 US 6836917			
Button			US 6189693		
Replaceable head				US 6836917	
Power Source					US 7137163

Patent US 4450599 is a patent for an electric toothbrush with a timer allowing the user to time how long they need to brush for by measuring the pressure on the bristles over time, until it goes off when it reaches a minimum pre-set amount. We will not be using this patent in our project.

Patent US 5867856 is a patent for the brush section of an electric toothbrush allowing the bristles to be oscillated rotationally around a transverse axis and gives a pivotal motion to the bristle structure along the longitudinal axis. We will likely be using sections of this patent in our project.

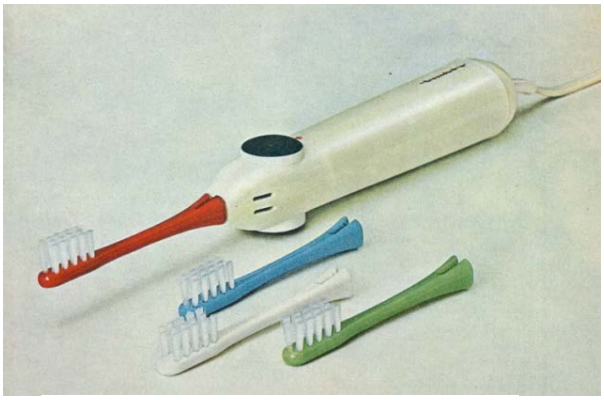
Patent US 6836917 is a patent for an electric toothbrush which has an elongated body with a head that has a moving bristle section and a static section. The head is also detachable. We will be using parts of this patent in our project.

Patent US 6189693 is a patent for an electric toothbrush containing brush head with a circular and static section. It also has a switch connected to the motor allowing it to operate momentarily and continuously. We will be using parts of this patent in our project.

Patent US 7137163 is a patent for a powered toothbrush with a handle containing a single battery which powers a motor connected to the brush head. We will be using technology from this patent in our toothbrush

4.3 Product Archaeology

The first electric toothbrush was invented in 1954 in Switzerland (History). The inventor was Dr. Philippe-Guy Woog and he named his toothbrush the Broxodent. Electric toothbrushes were first invented primarily for people with poor motor skills and disabilities or people with orthodontic gear (History). Today many people use electric toothbrushes due to the fact that they have a better cleaning effect and rely less on the technique of brushing. This toothbrush was later introduced to the United States but the electric toothbrush didn't become as popular until a new electric toothbrush was introduced with a few changes made to the design. The General Electric Automatic Toothbrush was introduced in 1961 and had rechargeable batteries making it a more convenient model compared to the Broxodent's power source which was a standard line plugged into a wall outlet (Dedicated). Even in the first few years that the electric toothbrush had been invented, inventors were already changing the model to better fit the needs of the customer. But still this toothbrush had many things to be improved upon to satisfy customer needs. The design of the toothbrush was bulky and the power source, although better than the Broxodent model, was still flawed. Today in the United States Broxodent electric toothbrushes can only be found online and bigger companies such as Philips Sonicare and Braun Oral-B have taken over the market for electric toothbrushes.



Original Broxodent Electric Toothbrush
bonanza.com

General Electric Automatic Toothbrush
ge.com

There are numerous styles and brands of the electric toothbrush, each one one upping the other with a feature the other doesn't have. There are features that customers are more concerned with than others. By analysing our survey we found these features to include the power source, replaceable brush heads, power button, and different speeds and modes. Over the years, these features have changed dramatically in many different models of electric toothbrushes. The earlier versions of electric toothbrushes were equipped with one speed. Most were bulky and uncomfortable to hold due to the battery size. The brush head didn't actually move it was more of a vibrating motion. Rechargeable models took a long time to charge and the charge didn't hold very long. Electric toothbrush companies then made some major changes to their models. They changed power sources and could now buy rechargeable or battery operated versions. Companies started making sleeker and more compact versions for easier portability and comfort. Also there were now replacement heads available for the toothbrush that the customers could buy. This made it so that the customer could use their main unit for a longer period of time which would save them money in the long run. There are toothbrush companies coming out with new models of electric toothbrushes every day. A few of the main companies people think of are Oral B, Philips, and Crest. It is very apparent how the

technologies of oral care and electric toothbrushes have changed. Oral B now offers toothbrushes with 3 different types of cleaning methods. There is a mode for whitening, another for sensitive teeth, and then a standard brushing method. Some models even have a mode for gum-massaging action (Oral B). One toothbrush package even includes a removable floss brush head (Oral B). There are brush head and toothbrush holders, storage units, and charges for travelling. Philips offers a toothbrush model with a brush head with sonic waves that brush your teeth instead of the standard oscillating brush head (Church). There are timers to keep track of how long you are brushing each quadrant of your mouth and even pressure sensors to prevent you from brushing to hard. They also offer many different types of brush heads and bristles to better fit each customer's unique teeth and mouth. Today electric toothbrushes are abundant in technology and features. These big companies will continue to improve their models and other companies will continue trying to put their electric toothbrush models on the map.

Figure 2. Oral-B Professional Care

electrictoothbrushhq.com

Table 5. Pros and Cons of Oral B Professional Care Smartseries 4000

Pros	Cons
Excellent cleaning ability	Cost of replacement brush heads
Long battery life	Bulky design
Built in pressure sensor	
Two minute timer	
4 Cleaning modes	
Pulsation, rotation and oscillation brush movements	

The Oral B Professional Care electric toothbrush is said to be one of the best electric toothbrushes on the market (Consumer). Table 5 shows a pros and cons table of the Oral B Professional Care Smart Series 4000. From this table it is easy to see that this toothbrush has many features that make it successful. But the table also shows cons. This tells us that although technology has come a long way, there are still flaws in even the best design of the electric toothbrush. We dissected our toothbrush into 13 different components. We thoroughly looked at each piece thinking of how we could come up with a better design and improve certain components of the toothbrush to satisfy the features we wish to change.

4.4. Benchmarking

In the following benchmarking table, I compared our original dissected brush to three other brushes on the market with similar prices. I compared them on eleven different criteria that we would consider in designing our brush. I then ranked the products on a scale of zero to five (zero being the worst and five being the best) on how well they performed in these criteria.

Table 6. Benchmarking of Four Products

Feature	**BrAun D4010 4739 (our toothbrush)**	**Oral-B Pulsar Pro Health**	**Crest Spinbrush Pro**	**Arm & Hammer spinbrush "Proclean"**
Packaging	2, small, all plastic, hard to open	5, Small packaging, cardboard back, Plastic package	1, Bulky, completely plastic, hard to open	1, larger to accommodate charger, all plastic, hard to open
Aesthetics	4, simple, mild coloring, slightly bulky	4, many colors, small, compact, hybrid manual/electric, large brush head	2, bad colors, large base, Spinbrush,	Compact, white and blue
Ease to clean	4, not many cracks, replacement heads	4, 1 piece, tough to clean in grip ridges.	2, large, many cracks	4, toothbrush easy to clean, has replacement heads
Convenience of on/off switch	4, Buttom to press, no switch	4, Button to press, no switch	3, switch, more reliable, harder to turn on and off	4, Button to press, no switch
Cleaning effectiveness	4, spinbrush, small head	2, average, no spin, slightly better than manual	4, spinbrush, small head	5, spinbrush+base part. Large head
Power source	Battery	Battery	Battery	Rechargeable
Noise level	2, loud vibration and motor	3, loud vibration, no motor noise	1, motor is loud	2, motor and vibration,
Cost	4, $10	4, $12.99 (Target)	5,$6.99	4, $15.96 (Sears)
Sustainability	3, battery powered, replacement heads	2, battery powered, no replacement heads	2, battery powered, no replacement heads	5, rechargeable, replacement heads
Portability	4, battery powered, slightly bulky	5, small, battery powered	3, bulky, battery powered	1, rechargeable base, bulky
Speeds and Modes	0, none	0, none	0, none	0, none

Figure 3. BrAun D4010
salestores.com

Figure 4. Oral-B Pulsar Pro Health
crest.com

Figure 5. Crest Spinbrush Pro
cheapism.com

Figure 6. Arm & Hammer Spinbrush "Proclean" recharge
consumerreports.org

4.5 Design Target

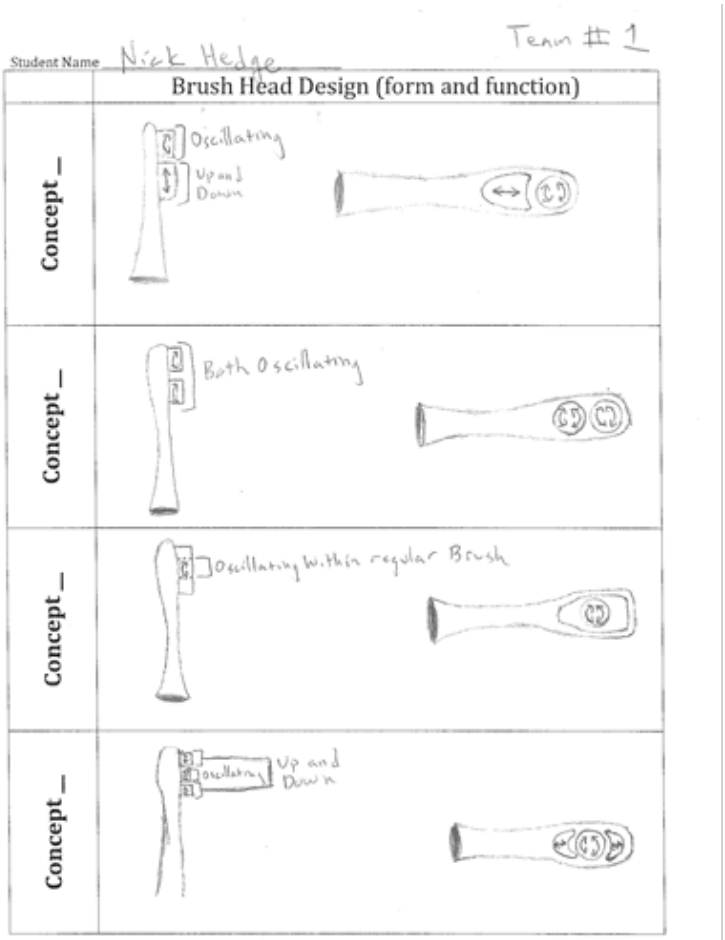
Based upon the external research and survey results a design target has been put together. We will want to work on the noise level of the toothbrush. To do this a smaller oscillation range will need to be used to reduce the vibration noise. To act upon the problems with comfort and grip, a smaller more compact and balanced base will be used. The grip will be symmetrical so that it is convenient for ambidextrous use. Based on the information that was found on other toothbrushes, the use of multiple speeds and cleaning methods should be included in our design because this is important to many customers and is apparent in almost all other models of electric toothbrushes. Power source and price are also going to be targeted in our design. The ability to be recharged is a feature that customers think to be important and this will be shown in our design.

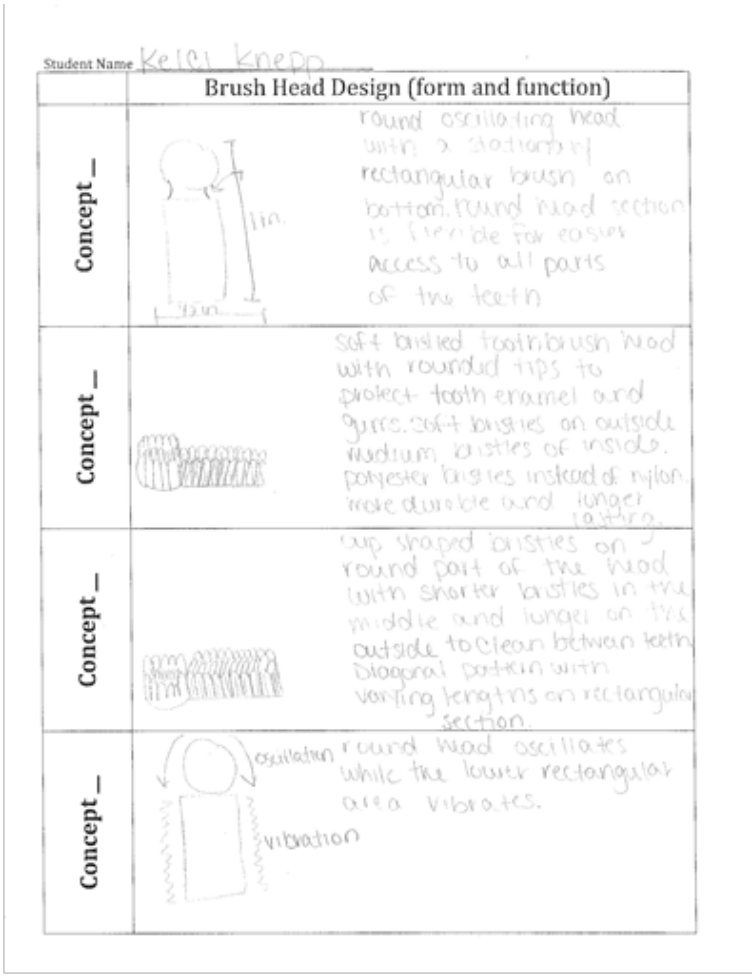
5.0 Concept Generation

5.1 Problem Clarification (optional)

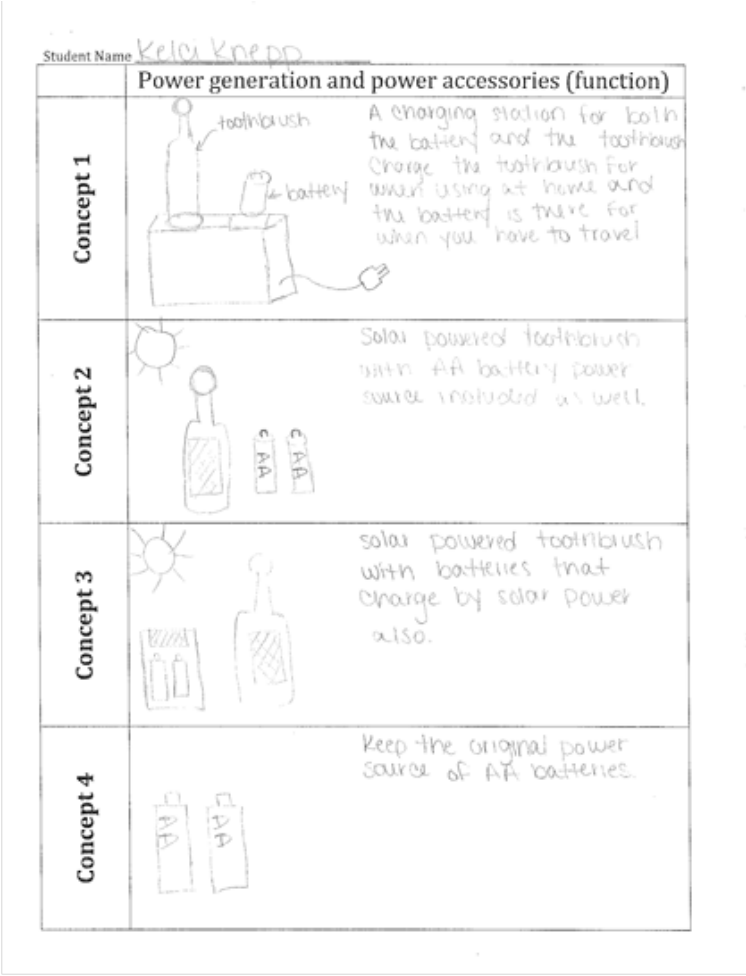
5.2 Concept Generation

The following brush head designs were based upon cleaning effectiveness, brush area, and originality. The brush head designs feature both vibrating and oscillating sections, different bristle patterns for different cleaning effectiveness, and different sizes.



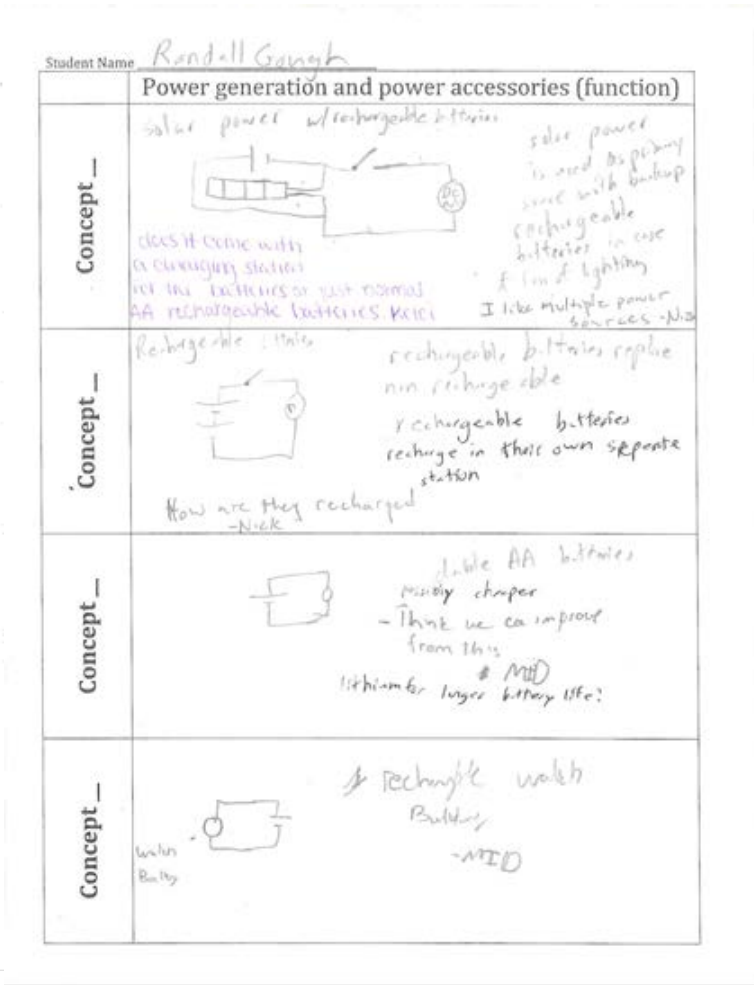


We came up with these power sources based on sustainability and practicality



Student Name Kelci Knepp

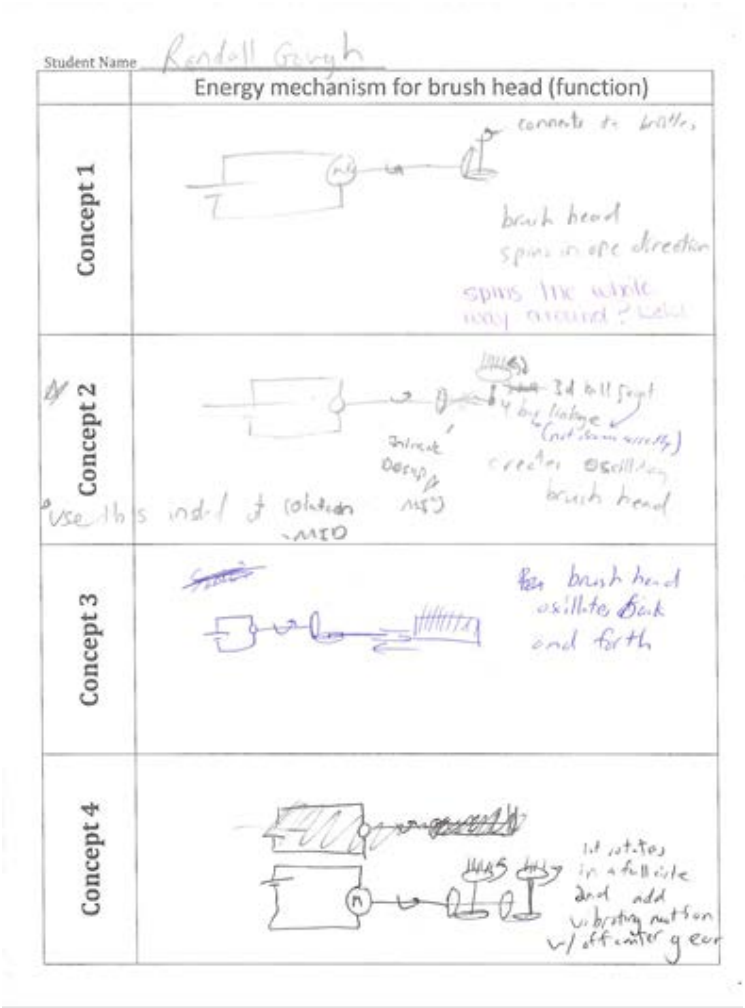
	Power generation and power accessories (function)
Concept 1	toothbrush, battery — A charging station for both the battery and the toothbrush. Charge the toothbrush for when using at home and the battery is there for when you have to travel
Concept 2	AA, AA — Solar powered toothbrush with AA battery power source included as well.
Concept 3	solar powered toothbrush with batteries that charge by solar power also.
Concept 4	AA, AA — Keep the original power source of AA batteries.

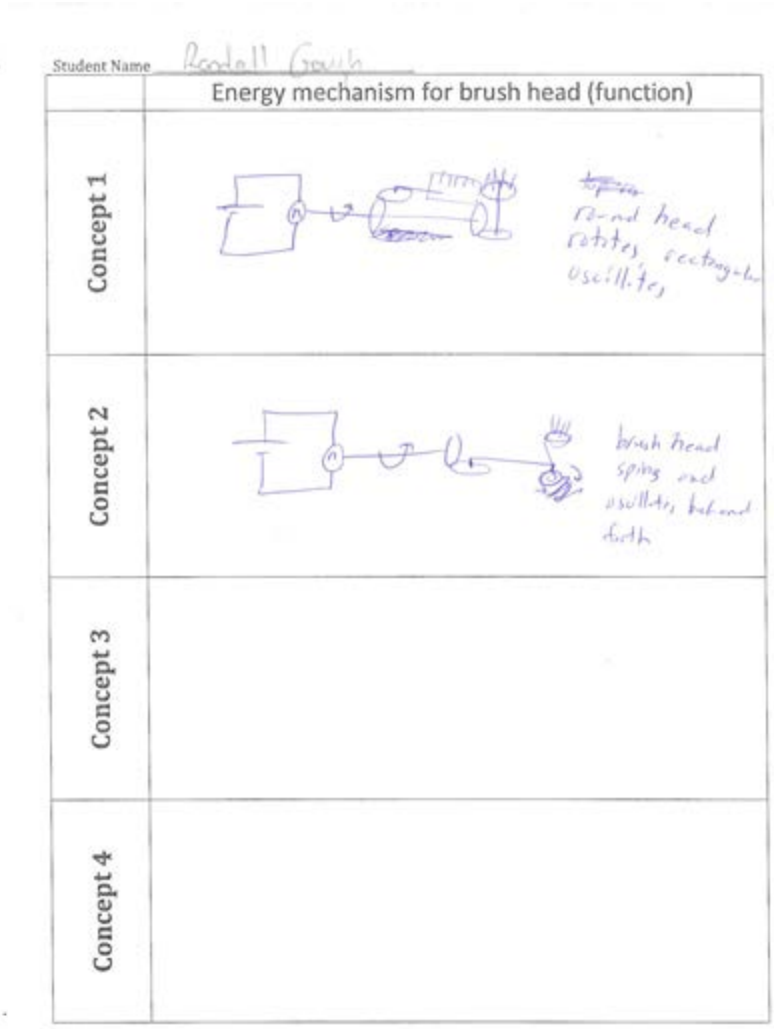


Student Name Randall Gough

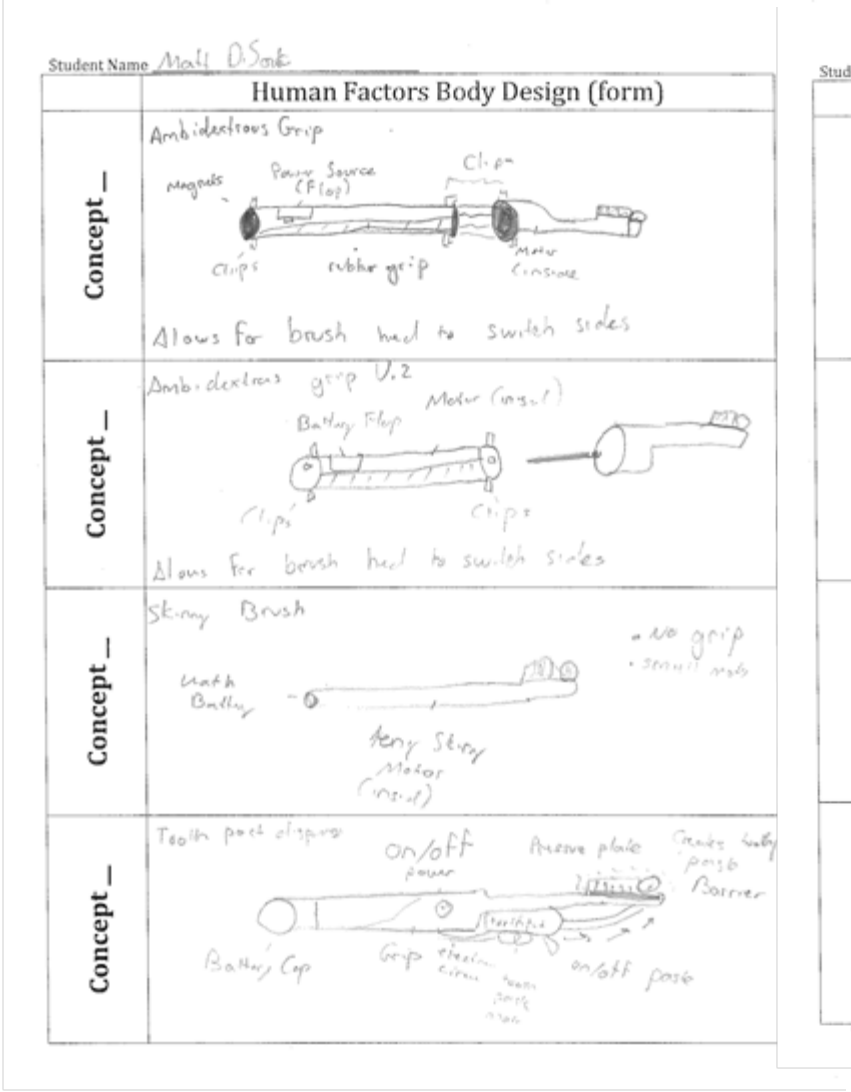
	Power generation and power accessories (function)
Concept _	solar power w/rechargeable batteries — solar power is used as primary power with backup rechargeable batteries in case of loss of lighting. I like multiple power sources -Nick. does it come with a charging station for the batteries or just normal AA rechargeable batteries. Kelci
Concept _	Rechargeable batteries — rechargeable batteries replace non rechargeable. rechargeable batteries recharge in their own seperate station. How are they recharged -Nick
Concept _	Little AA batteries — mostly cheaper. - Think we can improve from this. Lithium for longer battery life? -MID
Concept _	Rechargable watch Battery — watch Battery -MID

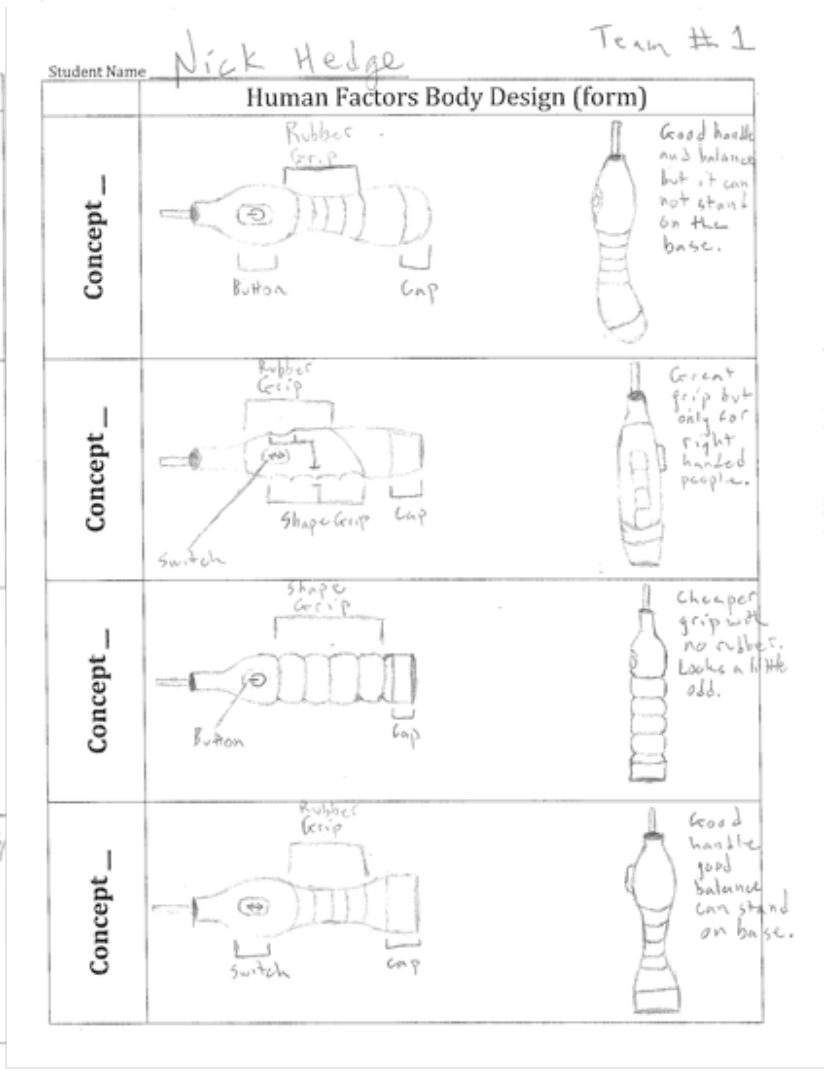
We came up with these brush head mechanisms based on the different ways we wanted our toothbrush to move.





We designed these body's based on comfort, looks, and portability





After sketching our concepts, we created the morphological chart below to narrow down our design possibilities.

Human Factors Body Design (form)	Power Generation and Power Accessories	Brush Head Design	Energy Mechanism for Brush Head
Concept 1 Hour Glass Rounded Cap	Concept 1 Solar Power With Rechargeable Batteries	Concept 1 Oscillating Top Vibrating Bottom	Concept 1 Brush head spins all the way around
Concept 2 Right Handed Brush	Concept 2 Rechargeable Batteries	Concept 2 2 Oscillating Brushes	Concept 2 1 Oscillating Brush
Concept 3 Molded Grip	Concept 3 AA Batteries	Concept 3 Oscillating Brush Inside Static Brush	Concept 3 Top and Bottom Vibrating Center Oscillating
Concept 4 Hour Glass Flat Cap	Concept 4 Alkaline Button Cell (Watch Battery)	Concept 4 Top and Bottom Vibrating Center Oscillating	Concept 4 Vibrating Brush
Concept 5 Ambidextrous Grip	Concept 5 Charging Station	XXXXXXXXXXXXXXXXXX	Concept 5 2 Oscillating Brushes
Concept 6 Skinny Brush	Concept 6 Solar Powered Brush with Solar Powered Battery Charger	XXXXXXXXXXXXXXXXXX	Concept 6 Oscillation Top Vibrating Bottom
Concept 7 Toothpaste Dispenser	XXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXX

6. Concept Selection

After the morphological chart we chose our final design with the Pugh charts below. We found our categories for the Pugh charts based on our surveys, but we weighted them based on our personal preferences. We weighted them on our own preferences because our survey sample was so small and slightly inaccurate

6.0 Final Design

Brush head Design

	Cost	Area	Effectiveness	Comfort	Durability	Total	Rank
Weighting	0.22	0.14	0.3	0.18	0.16	1	
1	1	1	-1	1	1	0.4	2
2	-1	-1	-1	1	1	-0.32	4
3	1	1	-1	-1	1	0.04	3
4	-1	1	1	1	1	0.56	1

Energy Mechanism for Brush Head

	Noise	Cost	Size	Durability	Effectiveness	Total	Rank
Weighting	0.1	0.12	0.14	0.31	0.33	1	
5	-1	-1	1	1	1	0.56	1
6	-1	1	1	1	-1	0.14	2
3	1	1	-1	1	-1	0.06	3
9	-1	1	1	1	-1	0.14	2

Human Factors, Body Design

	Cost	Sustainability	Portability	Size	Durability	Total	Rank
Weighting	0.28	0.1	0.18	0.26	0.18	1	
1	1	-1	-1	-1	1	-0.08	3
3	-1	1	1	-1	-1	-0.44	4
8	1	-1	1	1	1	0.8	1
2	-1	1	1	1	-1	0.08	2

Power Generation and Power Accessories

	Comfort	Cost	Appearance	Size	Durability	Total	Rank
Weighting	0.26	0.17	0.18	0.13	0.26	1	
2	-1	-1	-1	-1	1	-0.48	4
3	1	-1	1	1	-1	0.14	2
4	-1	-1	1	-1	1	-0.12	3
8	1	1	1	-1	1	0.74	1

6.1 Design Drawings, Parts List and Bill of Materials

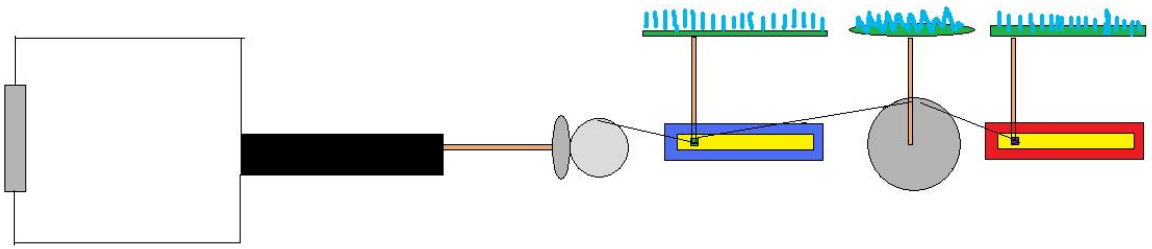
	Bill of Materials									
Part #	Part Name	QTY	SOP Effect	Function	Mass (pounds)	Material	Manuf. Process	Dimensions	Cost	Time to Complete Part Dissection
1	Lithium Watch Batteries	3	No	To power the toothbrush	.054	Metal, Lithium	Put chemicals into metal tubing	1in x .25in	$.5 - $1	Seconds
2	Battery cap	1	Yes	To hold batteries in place	.008	Plastic	Plastic mold	1 in x 1in c .5 in	cents	Seconds
3	Resistance bar	1	Yes	To apply force at the bottom of the base to keep the battery cap in place	0.002	Metal	Shape metal	1in x .5in	cents	Couple minutes
4	Brush cap	1	Yes	Keep bristle clean when not in use	.006	Plastic	Clear plastic put into a mold	cylindrical head: 11/16 inch diameter 11/16 inch height half cylinder base: 27/16 inch height 3/8inch to .5 inch diameter	$.01	1 second

5	Bristle	1	No	Cleans teeth by oscillation and vibration and, attached to motor	.002	Plastic/ metal	3 sections of plastic bristles mounted on the head (square, circle, square). Metal rod inserted through the middle	Cylindrical head	$.04	10 mins
6	Rod Holder	1	No	Covers and provides stability for the attachment between the motor and the brush head	.005	Plastic	Opaque plastic put into a mold	Cylindrical shape? 1 inch high 5/8 inch diameter Rectangular base? 13/16 inch length 5/8 inch width	$.05	20 mins
7	Brush Head Base	1	No	Covers interior moving parts	.006	Plastic/ metal	Opaque plastic put into a mold, metal rod attached through the top where the brush head connects	Cylindrical base: 19/8 inches long .25-.5 inch diameter Circular head: 3/8 inch diameter 5/16 inches wide	$.03	10 mins

8	Motor and brush rod	1	No	Convert electric energy from battery into mechanical energy	.088	Metal Wiring Plastic	Attach the motor to the brush rod with the wires attached to the power button	Wire length 2.25inches Motor 1.25inches by .75 diameter Brush Rod 2.8inches long	$.10	20 mins
9	Brush head base (inside)	1	No	Convert mechanical energy from the motor into the correct oscillating and vibrating motion of the brush	.002	Metal Plastic	Create plastic mold. Shape metal piece. Attach metal piece, plastic piece, and spring.	1.75inches by .25inch diameter	$.05	10 mins
10	Base Case (outside)	1	No	Keep all internal pieces together. Keep water from electric parts. Give comfort and grip	.044	Plastic Rubber	Create plastic mold. Create rubber mold. Glue rubber onto plastic.	5.65inches by 1.25 inch diameter	$.08	5 mins
11	Battery circuit component	1	No	Completes the circuit by connecting the two batteries	.004	Metal	Metal cut, shaped, folded and formed	Rectangular base: .85 in long, .25 in wide, .15 in high	$.05	20 mins

12	Base to head connector	1	No	Connects the base of the toothbrush to the toothbrush head component	.002	Plastic	Opaque plastic put into a mold with hollow middle	Cylindrical shape: .75 in long, .4 in wide, .05 in high	$.02	10 mins
13	Grip	1	Yes	Provides comfort while brushing	.02	Rubber	Rubber put into a thin, flat mold	Completely covers the base of the toothbrush	$.02	3 mins
14	Base Case Inside	1	No	Provides stability for the motor and components inside the toothbrush	.009	Plastic	Opaque plastic put into a mold	Cylindrical shape with a mostly hollow middle: 4.5 inches long about 1 inch wide	$.05	10 mins

6.2 How does it work?



Since most toothbrushes have only two moving parts, our design for mechanism had to be inventive. For the most part our design is similar to most other tooth brushes but with a small twists. Power is generated by the Power Source which in the photo is representing by the grey rectangle. The power source would then cause the motor (Black Box) to rotate the brown rod clockwise. As the rod rotates clockwise, a lever attached to a pivoting point would push the pivoting point back forth in straight line. This motion causes the bottom third of the toothbrush to move back and forth. Next the pivoting point would have a lever attach to a circular platform. The lever would be placed in the same place as it is on the first gear. To allow for oscillation the circular platform will have a larger diameter then the earlier gear. Since the distance needed to be covered will be greater the platform will not make full rotations. Instead the platform will oscillate the middle third of the toothbrush. Lastly for the top third to vibrate, another lever will attach to a pivoting point on a fixed axis will push and pull the last part of the toothbrush.

7.0 Conclusions

Based upon all of the findings and data from this experiment we have designed a more sustainable and customer friendly toothbrush. Our toothbrush is uniquely powered by 3 lithium watch batteries. To make this a more sustainable power source the recharge station is powered by solar energy with solar panels placed on the recharger. We have made the customers comfort a major factor in the design of our toothbrush. Our design is a well-balanced, hourglass shaped toothbrush to fit the hand of all users of our product. There is a 360 degree grip on the base of the toothbrush for ambidextrous use. The brush head is a unique design of 2 vibrating rectangular sections that surround an oscillating circular section for a more efficient and better cleaning.

References

Church & Dwight Co. (2012) Web. 23 Sep. 2012. <http://www.spinbrush.com/>

ConsumerSearch.com (2012) Web. 23 Sep. 2012. http://www.consumersearch.com/electric-toothbrushes/oral-b-professionalcare-smartseries-4000/specs

"Dedicated to Science & Research." GE. General Electric Company, 2012. Web. 12 Oct. 2012. <http://www.ge.com/innovation/timeline/eras/science_and_research.html>.

"History of Toothbrushes and Toothpastes." Brushing & Flossing: Use, Replacement & Technique of the Right Dental Products. Colgate, 12 June 2006. Web. 12 Oct. 2012. <http://www.colgate.com/app/CP/US/EN/OC/Information/Articles/Oral-and-Dental-Health-Basics/Oral-Hygiene/Brushing-and-Flossing/article/History-of-Toothbrushes-and-Toothpastes.cvsp>.

Proctor & Gamble (2012) Web. 23 Sep. 2012. <http://www.braun.com/>

Proctor & Gamble (2012) Web. 23 Sep. 2012. <http://www.oralb.com/>

Proctor & Gamble (2012) Web. 23 Sep. 2012. <http://www.crestprohealth.com/>

Appendix

Customer Electric Toothbrush Survey

1. Do you use an electric toothbrush?

2. If you answered no, why?

3. How much would you pay for an electric toothbrush?

4. Would you pay more for an environmentally sustainable toothbrush compared to a normal electric toothbrush?

5. Rate the following in order of importance (1 being least important):

- Appearance
- Different speeds and modes
- Cost
- Comfort
- Portability

6. Would you spend more on a rechargeable toothbrush compared to a battery operated one?

7. How many times a day do you brush your teeth?

8. Where do you use your toothbrush most?

9. How many centimeters would you say an average toothbrush head is?

10. Would the purchase of an electric toothbrush depend on its noise level?

11. Do you think there are any benefits of using an electric toothbrush compared to a regular toothbrush? If yes, briefly explain.

12. State the type of toothbrush you use. How many times a year do you buy a new one?

Lab 1

DATA SHEET 1

Getting Ready for Dissection: Part I

Manufacturer/Model Number: BrAun D4010 4739

General Product Information:

How many detachable pieces the product has? 5

Part number:	Part name:
_____1_____	Base
_____2_____	Brush Head
_____3_____	AA Batteries
_____4_____	Battery Cap_
_____5_____	Brush Head Cap

Describe the pieces including their functions and their materials.

Part number:	Material & Functional Description:
_____1_____	Plastic - Handle / Motor
_____2_____	Plastic - Scrub teeth
_____3_____	Metal & Chemicals – Provides Energy
_____4_____	Plastic – Provides protects motor and batteries and holds them in place
_____5_____	Plastic – Keeps brush head clean during storage

Is it easy to detach each part?

Part number:	Detachment (Easy, difficult, use of force etc.):
_____1_____	Easy
_____2_____	Easy
_____3_____	Easy
_____4_____	Medium *needs a little force
_____5_____	Easy

Describe the packaging. Is it easily opened? Describe the opening procedure.

The packaging is a molded plastic that surrounds the toothbrush. Its design is to be able to show its product and be hung on a shelf in a store. In order to do this, the packaging gives up convenience when opening it. To open one must use a sharp object to cut away the plastic.

DATA SHEET 1	
Getting Ready for Dissection: Part I (cont.)	
Product Features: Provide team's collective opinion related to features of the product using the following list as a starting point.	
Packaging (including information insert)	Team- we hate the packaging, it's not easy to open, and the information provided is useless. The packaging is also not environmental friendly.
Aesthetics (multi-color, etc.)	Team – Handle is bulky and abnormally large. The green color is very nauseating.
Cleaning	Team – Easy to clean bristles and replace part when dirty
On/off switch location	Team – Locations is good/ right where our thumbs settle naturally
Battery location	Team - Battery Locations is optimal, easily removable, and out of the way.
Ease of switch use	Team - button is soft enough to turn on with ease, hard enough to prevent accidental shut down.
Handle (Ergonomics)	Team – ambidextrous, but clearly made for the use of righty's, but lefties can use with minimal difference
Quality	Team – Good Quality
Safety	Moderately Safe – under the brush head has a sharp edge and could impale themselves, Brush Head Cap is could be swallowed by an infant
Versatility, attachments	Batteries can be used in any electronic device, can be used to clean floors
Weight with batteries	Not noticeably heavy
Environmental friendliness	Packaging is very unfriendly, but is more friendly than a regular toothbrush due to is longevity

DATA SHEET 1	
Getting Ready for Dissection: Part II	
Cost (Be prepared to record multiple values and sources)	Tooth Brush 1 = $10.99 http://www.just4teeth.com/Oral-B-Advance-Power-400_2 Tooth Brush 2+ = $9.99 http://www.just4teeth.com/Oral-B-Advance-Power-400_2 AA Batteries 8pck = $8 - $15 http://www.radioshack.com/family/index.jsp?categoryId=2032150&allCount=76&fbc=1&f=PAD%2FProduct+Type%2FAA&fbn=Type%2FAA&filterName=Type&filterValue=AA&utm_source=Google&utm_medium=PPC&utm_term=AA%20Batteries&utm_content=Exact&utm Brush Head replacements 3pk = $16.99 -$19.99 http://www.theessentials.com/products/oral-b-advancepower-400-replacement-parts.jsp
How long has the product been in the market?	9 years. Copyrighted in 2003
Target population	Children and adults 12 and older
Versions of the product (Previous versions of the product)	Vitality Sonic, Vitality Precision, Procare 500, Procare 1000, Procare 2000, Procare 3000, Triumph 4000, Triumph 5000
What are improvements between versions of the product?	The newer versions offer you more brushheads, a different power source, different brushheads, brushing modes, cleaning methods, and timers
How is it sold (TV infomercial, drugstores, etc.)	TV commercials, drugstore ads, dental offices
Patented Features (Please include patent dates).	Grip pad for an electric toothbrush handle- Jan 9 2007 Electric toothbrush handle- Jan 9 2007 Tooth brush- Oct 12 2010

DATA SHEET 2 Lab 2

1. Noise Measurement:

Location:	Noise level:
Brush head 4 in away from decibel meter	___77.5_dB_____
Brush head 3 in away from the decibel meter	___78___dB_____
Brush head 2 in away from decibel meter	___79___dB_____
Brush head 1 in away from the decibel meter	___81___dB_____
DC motor 4 in away from decibel meter	___74.5__dB_____
DC motor 3 in away from the decibel meter	___75.5__dB_____
DC motor 2 in away from the decibel meter	___76____dB_____
DC motor 1 in away from the decibel meter	___76.5___dB_____

Approximate duration of brushing per day:	___4 Minutes____
Average noise level during brushing:	___78.86 dB_____

2. Power Measurement:

Voltage supplied to the circuit:

Battery Type	Volts (V):	
Battery 1	Duracell AA	1.533 V
Battery 2	Duracell AA	1.533 V

Total Voltage:

Connection Type	Volts (V):	
Battery 1 and Battery 2	Series	3.06 V

Current Measurements	Averaged Current Value
No load condition	.241 A

Load condition(s)

1. Kelci	.300 A
2. Matt	.260 A
3. Randall	.330 A
4. Nick	.330 A

Mean current ‘under load’ .305A

Voltage Current

Power (no load) = 3.06 V X .241 A = .737 Units: W

Voltage Current

Power (under load) = 3.06 V X .305 A = .933 Units: W

3. Battery Life

1. Number of hours available per single battery ‘under load’ conditions: ___7.9___Hours

2. Estimate duration for each brushing _____.0666_____ Hours

3. Number of days before battery replacement ___118.033_____ Days

	Bill of Materials										
Product Manufacturer/Model Number: BrAun D4010 4739											
Date: 9/17/2012											
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 (pounds)	Material	Manuf. Process	Dimensions	Cost	Time to Complete Part Dissection
Matt	1	Batteries	2	No	To power the toothbrush	.054	Metal, Alkaline	Put chemicals into metal tubing	1in x .25in	$.5 - $1	seconds
Matt	2	Battery cap	1	yes	To hold batteries in place	.008	Plastic	Plastic mold	1 in x 1in c .5 in	cents	Seconds
Matt	3	Resistance bar	1	yes	To apply force at the bottom of the base to keep the battery cap in place	0.002	Metal	Shape metal	1in x .5in	cents	Couple minutes
Randall	4	Brush cap	1	Yes	Keep bristle clean when not in use	.006	Plastic	Clear plastic put into a mold	cylindrical head: 11/16 inch diameter 11/16 inch height half cylinder base: 27/16 inch height 3/8inch to .5 inch diameter	$.01?	1 second

Randall	5	Bristle	1	No	Cleans teeth by rotating back and forth, attached to motor	.002	Plastic/ metal	Plastic bristles mounted on the head. Metal rod inserted through the middle	Cylindrical head: .5 inch diameter 7/16 inch width Cylindrical protrusion off back: 3/16 inch diameter ¼ inch width	$.04?	10 mins
Randall	6	Rod Holder	1	No	Covers and provides stability for the attachment between the motor and the brush head	.005	Plastic	Opaque plastic put into a mold	Cylindrical shape? 1 inch high 5/8 inch diameter Rectangular base? 13/16 inch length 5/8 inch width	$.05?	20 mins
Randall	7	Brush Head Base	1	No	Covers interior moving parts	.006	Plastic/ metal	Opaque plastic put into a mold, metal rod attached through the top where the brush head connects	Cylindrical base: 19/8 inches long .25-.5 inch diameter Circular head: 3/8 inch diameter 5/16 inches wide	$.03?	10 mins

Nick	8	Motor and brush rod	1	No	Convert electric energy from battery into mechanical energy	.088	Metal Wiring Plastic	Attach the motor to the brush rod with the wires attached to the power button	Wire length 2.25inches Motor 1.25inches by .75 diameter Brush Rod 2.8inches long	$.10	20 mins
Nick	9	Brush head base (inside)	1	No	Convert mechanical energy from the motor into the correct oscillating motion of the brush	.002	Metal Plastic	Create plastic mold. Shape metal piece. Attach metal piece, plastic piece, and spring.	1.75inches by .25inch diameter	$.05	10 mins
Nick	10	Base Case (outside)	1	No	Keep all internal pieces together. Keep water from electric parts. Give comfort and grip	.044	Plastic Rubber	Create plastic mold. Create rubber mold. Glue rubber onto plastic.	5.65inches by 1.25 inch diameter	$.08	5 mins
Kelci	11	Battery circuit component	1	No	Completes the circuit by connecting the two batteries	.004	Metal	Metal cut, shaped, folded and formed	Rectangular base: .85 in long, .25 in wide, .15 in high	$.05	20 mins

Kelci	12	Base to head connector	1	No	Connects the base of the toothbrush to the toothbrush head component	.002	Plastic	Opaque plastic put into a mold with hollow middle	Cylindrical shape: .75 in long, .4 in wide, .05 in high	$.02	10 mins
Kelci	13	Thumb grip	1	Yes	Provides comfort while brushing	.002	Rubber	Rubber put into a thin, flat mold	Ovular shape 1.5 in long, .85 in wide,	$.02	3 mins
Kelci	14	Base Case Inside	1	No	Provides stability for the motor and components inside the toothbrush	.009	Plastic	Opaque plastic put into a mold	Cylindrical shape with a mostly hollow middle: 4.5 inches long about 1 inch wide	$.05	10 mins

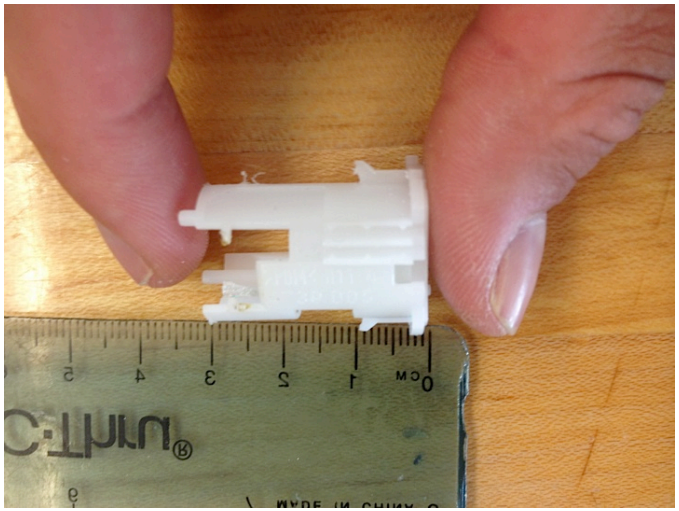
Visuals: Component pictures, sketches and/or solid models (place team members name who completed each visual)	
Figure . Rod Holder 	Figure . Base Case Outside

Figure . Battery

Figure . Resistance Bar

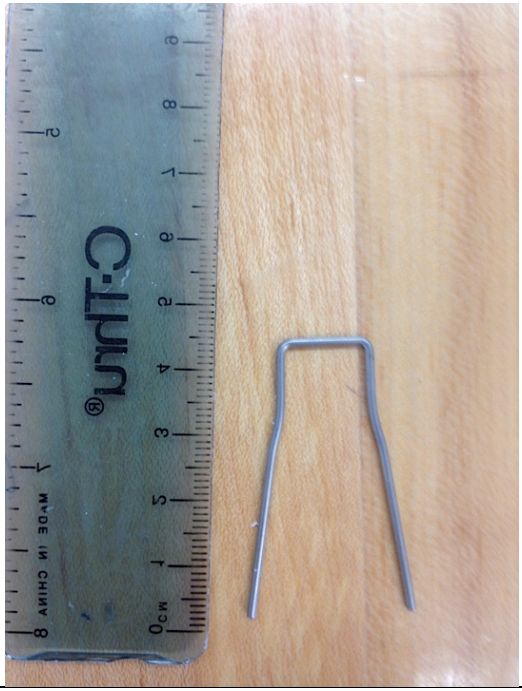
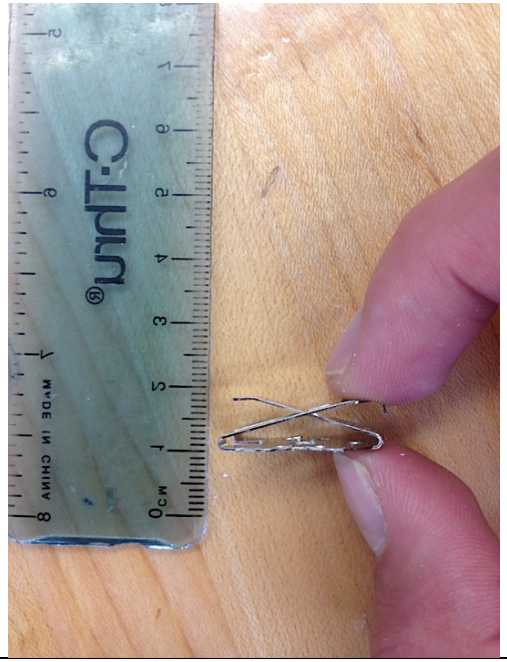


Figure . Battery Circuit Component 	Figure . Battery Cap

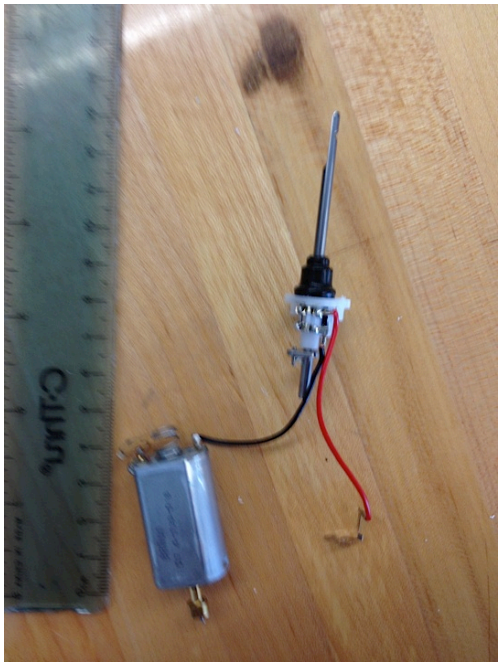


Figure . Motor

Figure . Brush cap

Figure . Base to Head Connector

Figure . Brush Head Base

Figure . Bristle

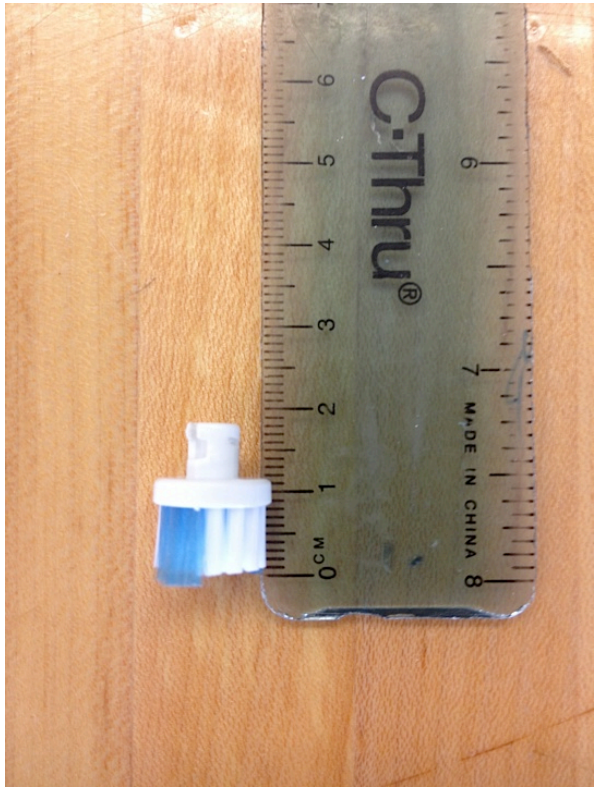


Figure . Thumb Grip

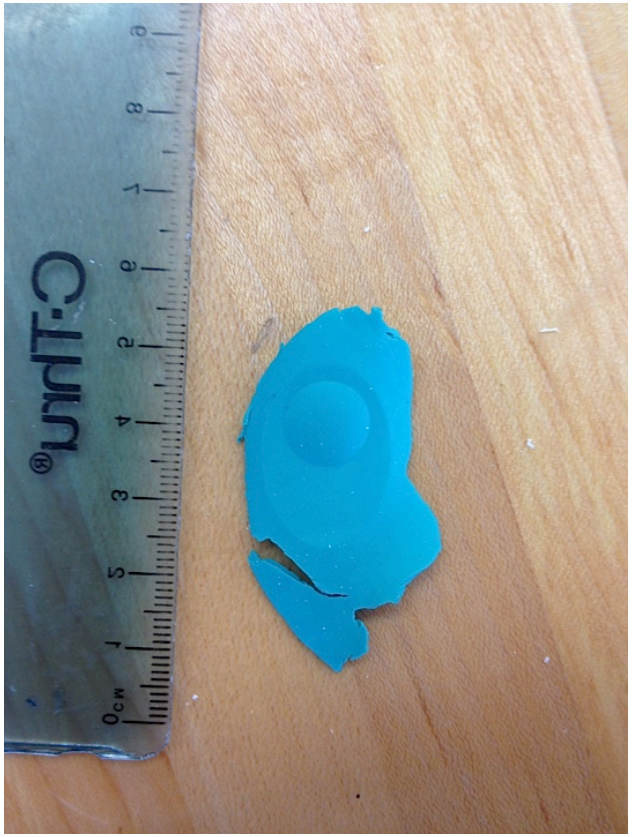


Figure . Base Case (inside)

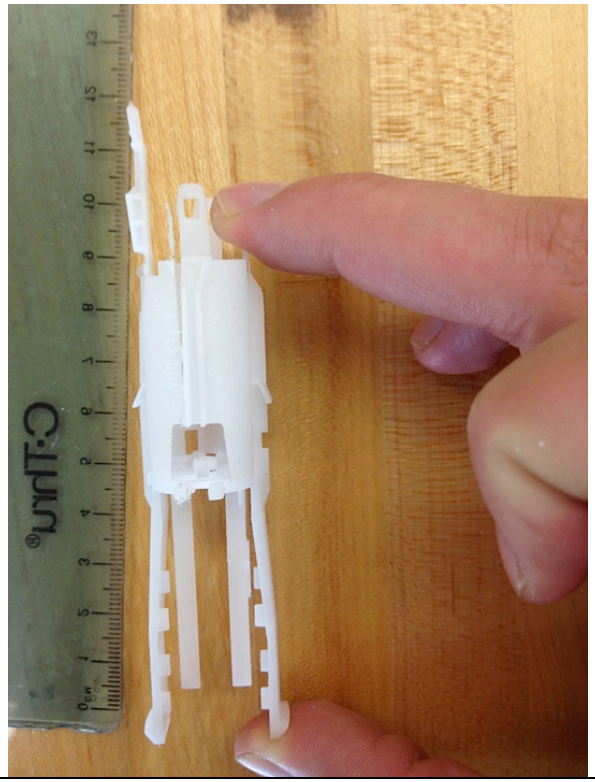
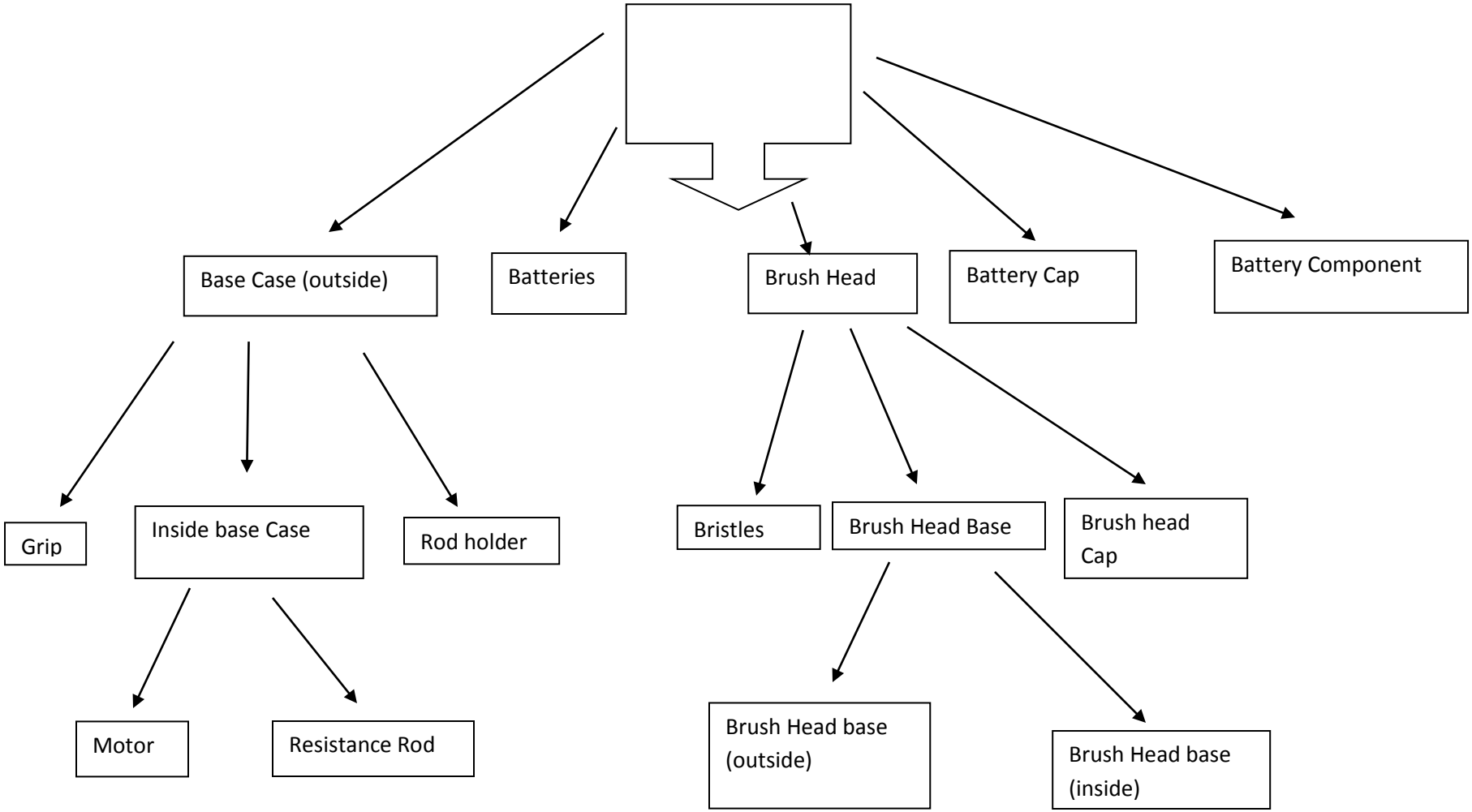
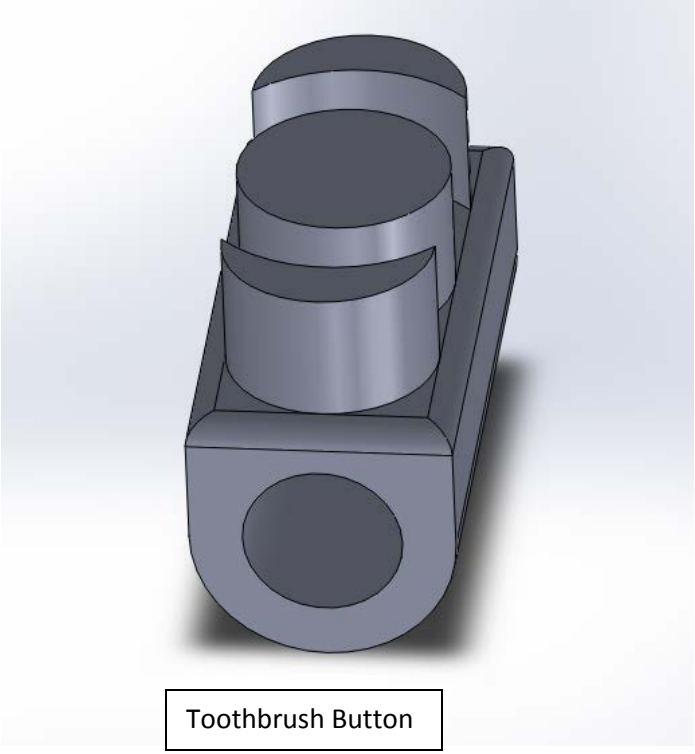


Figure . Brush Head Base Inside

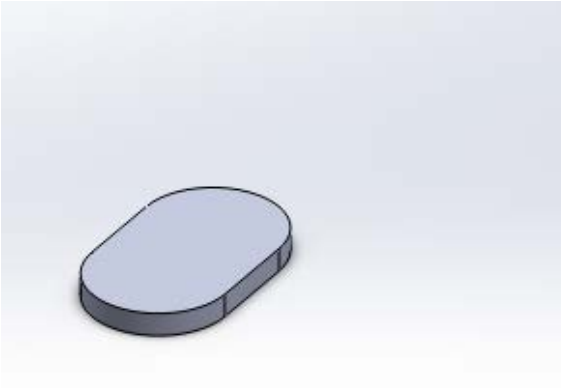

Base Case (outside)
Batteries
Brush Head
Battery Cap
Battery Component
Grip
Inside base Case
Rod holder
Bristles
Brush Head Base
Brush head Cap
Motor
Resistance Rod
Brush Head base (outside)
Brush Head base (inside)

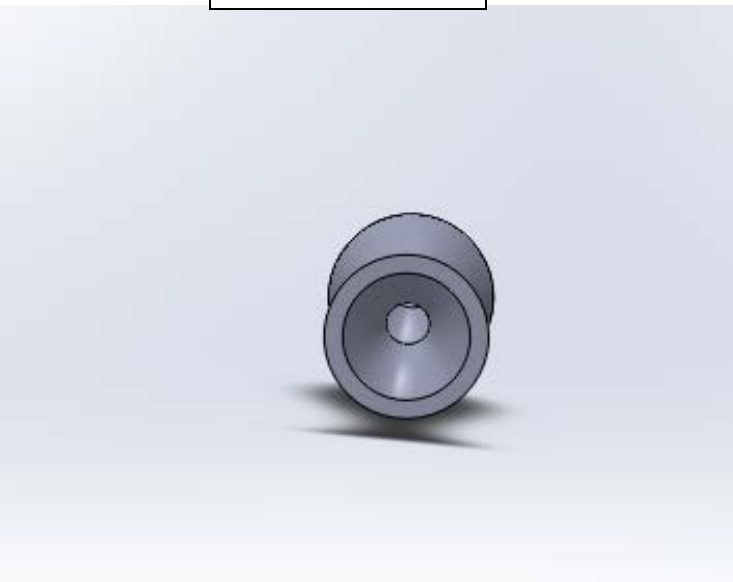
Toothbrush Neck



Toothbrush Button

Toothbrush End Cap



Toothbrush End Cap

Toothbrush Body