Crayon the Chameleon

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ENGR 2920
DESIGN METHODOLOGY
MAY 10th, 2016

TABLE OF CONTENTS

ABSTRACT

On February 23rd, the team, D is for Design, was tasked with designing and prototyping a toy, which was to include a mechanism to perform a specific task for the entertainment of young children. The goal was simple: to implement design methodology and create the best toy we could possibly create. It was decided this toy will be affordable, cute, robust, have low power usage, and become the center of attention when it is used. After numerous intense brainstorming sessions, the team conceided upon the idea of a chameleon. We were inspired through the use of the C-K mapping technique to combine our trained expertise of circuitry and programming with biologically-inspired design to create the chameleon, christened hereby as Crayon the Chameleon. Crayon is to be sewed together into the shape of a chameleon. The reason for this name, is that like real-life chameleon's, Crayon is to possess the ability to change his color at will. This task is accomplished through the use of bright multi-colored LED's that shine through the outer layer of Crayon. These LED's are programmed to change color over time, imitating the chameleon's ability to blend into nearby surroundings. Along with the cute outer appearance, Crayon the Chameleon became our efforts, hopes, and dreams colored into reality.

NARRATIVE

Life full of Colors

There's a legend from long ago, that tells the story of a chameleon, just like us. His name was Crayon. They say he was the first chameleon who learned how to change colors.

One day Crayon was walking through the forest, when it started to rain. He seeked shelter, and hid until the rain was gone. When he stepped outside, what he saw before him he will never forget. A rainbow, named Crayola.

Crayon fell in love with the rainbow. They spent every moment together, but back then, a chameleon and rainbow couple was seen as a disgrace. The high clouds did not think a relationship between a heavenly rainbow and a lowly chameleon was natural. Even so, Crayola loved him back with all of her colors. They promised each other to spend the rest of their days together, and they lived happily ever after.

Until one day, Crayon woke up, and the rainbow was gone. Crayon panicked. He knew Crayola would never leave him. He knew something was wrong, so he began walking to find Crayola. Some say he walked the whole world looking for the rainbow. He looked through every mountain, every storm, every night, just for that rainbow.

Then one day, when Crayon could walk no more, he sat down. Legend says that the emotion that is Crayon suddenly came to life within him. The color shined through Crayon. He himself became a rainbow. His light shined throughout the world, throughout the universe. It shined so far, that even Crayola saw it from where rainbows go when they disappear. She cried. She

thought she would never see him again. It had been years since she last saw him, but she knew the glow of Crayon even when it was just inside of him. She went to him.

Crayon knew he was right all along. He knew Crayola would never leave him. Crayola had been forced away from Crayon because he was a chameleon and she was a rainbow. The clouds had taken Crayola away from Crayon. They forced their societal judgements on the two lovers. But now, Crayon ascended past a chameleon, past a rainbow itself. Crayon was able to shine his light so bright that not even the clouds could block his love. Crayola never cared that the clouds disapproved. She never cared if she was a rainbow, and he was just a chameleon. All she cared about was Crayon. All she cared about was that she had found Crayon again.

And from then on, they shined together, forever.

Do you know how at dusk, for just a few short minutes the sky completely changes color to a bright passionate red? That's Crayon and Crayola's love that still shines to this day. Their love remembers that even when they were so far apart, when they were forced so apart, all they dreamed of every night was seeing each other for just a few more short minutes.

BACKGROUND

The modern day chameleon is descended from the ancient anqingosaurus brevicephalus, which is estimated to have lived between 2.5 - 5.3 million years ago (Maisano). There are about 160 to 200 different species of chameleons, most of which are native to sub-Saharan Africa (Cornett). Chameleons are insectivores and consume smaller insects by extending their sticky tongue. Chameleons are found all across the world, such as in southern Europe, Asia, and the middle east. They typically inhabit rainforest and desert biomes where they are usual predators in their ecosystems. Chameleons are frequently confused with their lizard cousin, the gecko. The main external distinguishing features of the chameleon would be the curled tail and the protruding independently controlled eyes, as in the in the image to the right (Siwanowicz). The most notable feature of the chameleon is most likely their ability to change their outward skin color to blend in with their surroundings. To change their skin color, chameleons have a layer of crystals above their pigmented skin cells, which they have the ability to change the distance between these crystals. By changing the distance of the crystals, this causes the skin to reflect different colors of light, allowing them to change skin color (Edmonds). This has proved to be very beneficial to chameleons, as it allows them to hide from predators, and ambush prey.

The reason team D is for Design chose the chameleon as the center of our project is because we wished to raise awareness for this adorable and defenseless creature of the night. Thirty-six percent of the world's chameleons are in danger of being extinct. The number raises to nearly fifty-five percent once all threatened species are accounted for (Hance). We believe this number is far too large and should be closer to zero percent. The reason chameleons are in danger is because of anthropogenic impacts on the environment. Humans are the cause of biome destruction, not limited to desertification and deforestation which destroys the habitats of the animals that live there (Reese). Chameleons are specifically in danger because they frequently live in one concentrated area. For this reason, we want Crayon to become the lord and savior of chameleon salvation and habitat conservation.

Technical Requirements

Crayon the Chameleon should:

- Have a main body of length less than 60 cm.
- Should resemble a chameleon.
- Have a transparent or non-opaque external layer.
- The physical dimensions should be within 60cm x 20cm x 30cm.
- Outer layer should protect and cushion the inner electrical components.
- Operate on at most a 9V battery, or three AA batteries.
- Use multi-colored LED.
- Use a microcontroller to operate LEDs.

The figure to the right shows one of the competitive products available on the market (Disney Tangled Rapunzel Chameleon 8" Plush Toy). As evident, this chameleon toy does not change color and is clearly not adorable enough to our standards.

DESIGN OBJECTIVE

According to the assignment, the design objective of this project is to design a toy for kids. We wish to provide a new generation of plushy toys for children of ages five to eight. We did not want to impose bias onto our clientele. This toy was destined to appeal to all children and genders from the very beginning. We wanted to show our target demographic something entirely new and novel. Crayon is the cumulation of different societal impacts. The purpose behind Crayon was to educate children about the environment while incorporating nature aspects, medical aspects, and entertainment, as this is what we intended to do. Crayon is to teach children about the environment by being shipped with a complementary pamphlet that describes the plight of the chameleon and its habitat. Potentially, we would like to see a television series or young-adult novel franchise starring Crayon enter production to further stress concern about nature. At the very least, Crayon will be able to measure the temperature of the user and teach the user about human body temperature and homeostasis, therefore teaching the user about medical aspects of the human body. Not only that, Crayon is full of light that will shine through boredom as these lights are unapologetically fantastic. These considerations were all included when designing Crayon. By using its cute and cuddly appearance, Crayon is systematically designed to become the symbol for chameleon habitat conservation.

Customer and Customer Requirements

Crayon's customer's include a wide variety of stakeholders who are invested in the product. These include but not limited to:

- The target consumer
- Management
- Faculty evaluators
- Manufacturing personnel
- Designers
- Programmers

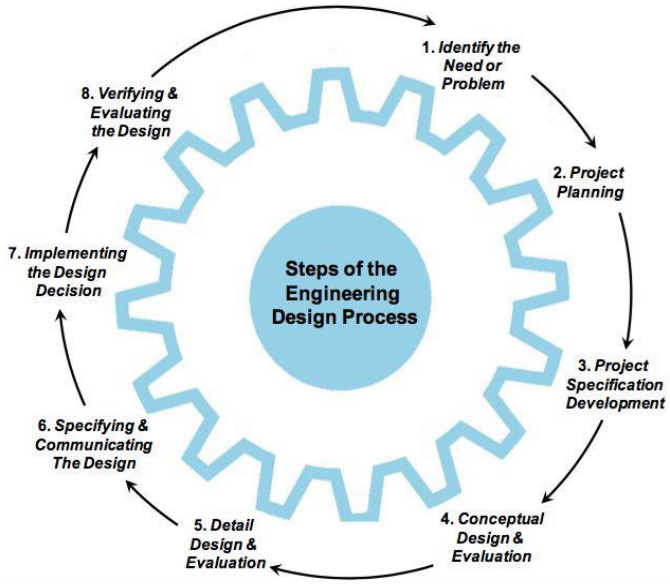
Some of the customer requirements are as follows:

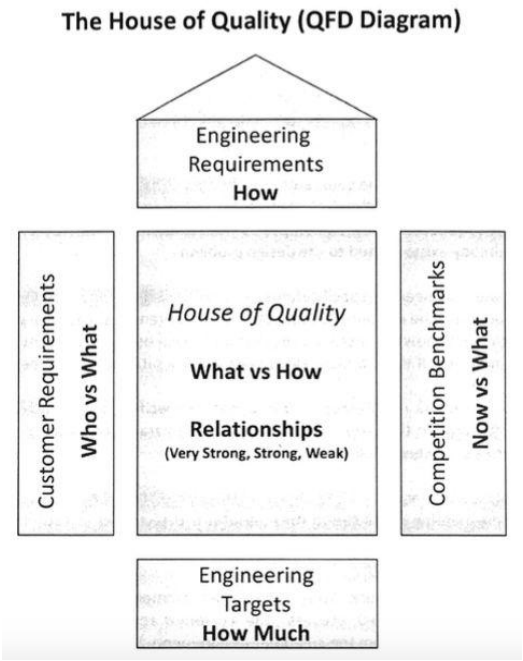
- Product must be safe to children under expected use.
- Product should operate quietly.
- Product should use as few parts as possible for easier manufacturing.
- Product should be adorable.
- Product should resemble a chameleon.
- Product should be colorful.
- Product should require little to no maintenance.
- Product should be portable and not require a DC power outlet to function.
- Product should implement design methodology.
- Product should not be a major contribution to environmental pollution.
- Product should be durable under expected use.
- Product should be high quality.
- Product should require little to no set-up or installation time.
- Product should measure temperature.
- Product should cost less than $50.

1) Identifying the Need
    a) Children need a new adorable chameleon plush toy that lights up different colors.
2) Project Planning
    a) Phiet Do assigned as team leader, assigning roles to other team members.
    b) Phiet Do was to supervise the project development and the actual sewing of Crayon.
    c) Luis Perea was to write the report and kept a design notebook.
    d) Jey John Britto was to write and test the code for the LED and temperature sensor interaction feature.
    e) Marvin Guerrero was to create a prototype using CAD software.
    f) Jay Patel was to create a video for the project.
    g) A Gantt chart was prepared to keep on schedule.
3) Project Specification Development

a) The team performed benchmarking and analyzed requirements for the product using the QFD diagram.

4) Conceptual Design and Evaluation
    a) The team used C-K theory to create a conceptual design of Crayon.
5) Detail Design & Evaluation
    a) The team created a prototype using CAD software.
6) Specifying & Communication the Design
    a) The team came together to state their input on the potential design, and refined any details that were necessary.
7) Implementing the Design Decision
    a) The plush product was sewn together.
8) Verifying & Evaluating the Design
    a) The team performed benchmark analysis, and made sure that a sufficient amount of customer and engineering requirements were met.





The two figures above summarize the design process we implemented in designing Crayon (Pidaparti). There are several steps to the design process, and several considerations within each step, such as the QFD diagram. The QFD diagram helped with separating and evaluating the different design choices and settling into a final design based on what was important to the different stakeholders and engineering requirements.

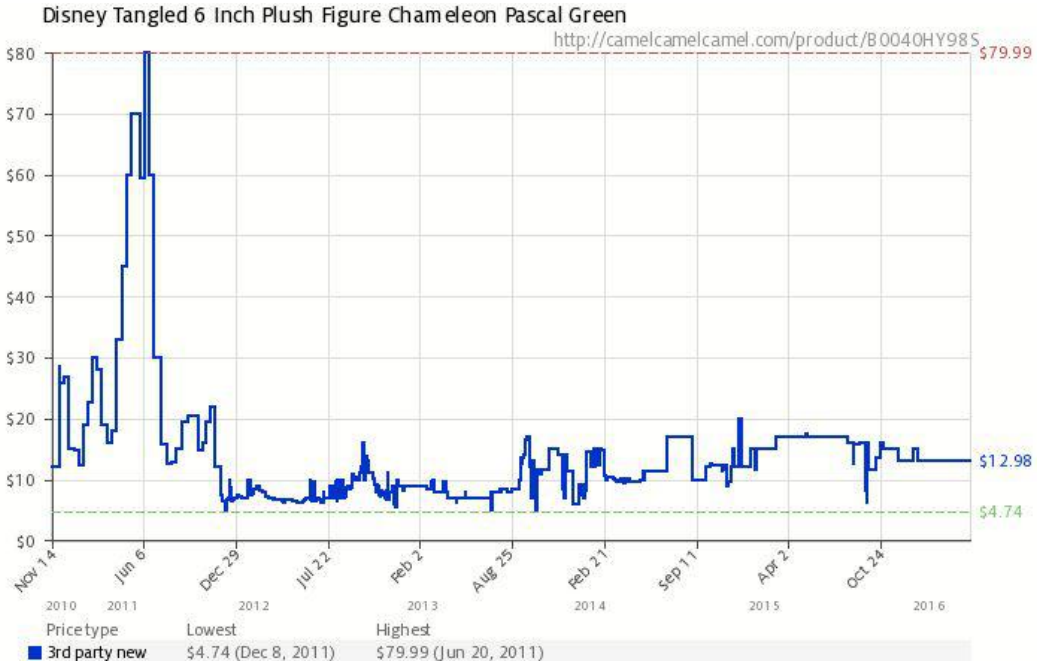
Engineering Requirements

Crayon's engineering requirements were thought of in accordance to what we wanted to design, the best toy ever, with what was within the realm of our knowledge expertise and reasonable feasibility. They include but not limited to:

- The physical dimensions should be within 60cm x 20cm x 30cm.
- Operate on at most a 9V battery, or three AA batteries.
- Battery life usage should be at least 5 hours.
- The plushie exterior should be durable and hold its shape for at least a year.
- The individual LED's should have low power consumption.
- The LED's should not produce blinding light.

BENCHMARKING

While we were creating Crayon, we looked into the different competing products and existing designs. The concept for a plush chameleon is not new to us or to the market, and sales for this type of product had risen exponentially around late 2010 and early 2011 due to the release of Disney's "Tangled".



In recent years, demand for a chameleon plush product has reached an all-time low, and we felt the market is ripe for the taking. Currently, the competitive product includes a generic chameleon plush, as seen in the figure to the right. While this is a great product, we feel that it does not meet all of the customer requirements placed upon Crayon. Analyzing for some customer requirements, we conclude that:

- Product must be safe to children under expected use. - MET
- Product should operate quietly. - MET
- Product should be adorable. - NOT MET
- Product should be colorful. - NOT MET
- Product should measure temperature. - NOT MET.

Therefore, we do not feel that this product serves as an adequate comparison to Crayon. Another notable competitor would be a star plush pillow with the ability to shine different colors, named the “Light up Star Pillow”, as seen in the figure to the right. This pillow would serve as the most direct competitor to Crayon. While the Star Pillow and Crayon are not similar physically, they share the main selling-point feature in the form of being a light-up plush toy of multiple colors. However, the general premise is different from Crayon. The star plushie is more suited for a sleeping-pillow, while Crayon is intended to educate and entertain. Analyzing some customer and engineering requirements, we conclude that:

- Product should measure temperature. - NOT MET
- Product should cost less than $50. - MET
- Product should be portable and not require a DC power outlet to function. - MET
- Product should be adorable. - MET
- Product should be colorful. -MET
- Product should resemble a chameleon. - NOT MET
- Operate on at most a 9V battery, or three AA batteries. - MET

While the light-up pillow star does meet several of the customer requirements, it is safe to say that the target market is different. The pillow star is targeted to people of all ages, Crayon is specifically designed to appeal to young children to educate them about chameleons. Not only that, the star pillow lights up in multiple colors at once, while Crayon transitions from one color to the next, therefore, the pillow is designed to resemble a star, while Crayon is designed to resemble a chameleon. For these reasons, we concluded that there is not a direct competitor to Crayon.

DESIGN CONCEPTS

C-K Theory

In the beginning, we first used the C-K Theory for brainstorming to come up with an idea for our project. We knew we had to mimic biology, so we considered aspects from plants, cells, and animals, since we needed to implement a specific mechanism. Common mechanisms found in nature are homeostasis, chain reaction mechanisms, nature mechanisms, and crypsis, which are ideas we simply knew as concepts.

For the knowledge space, we knew that there are animals with defense mechanisms, such as the armadillo, chameleon, frog, and porcupine.

From there, we developed our concept space to be narrowed to two concepts:

1) Mimicking an an armadillo
    a) Reinvent a standard playing ball
    b) Transform shape
    c) Already exists
2) Mimicking a chameleon
    a) Create a toy that changes colors
    b) React to changes in the area or atmosphere

We therefore decided to use a chameleon as the basis for our project after taking a majority vote. This was a simple decision as the armadillo idea for a transforming ball was already taken, and the porcupine and frog would only bring negative connotation of punctures and poison defense mechanisms. Furthermore, it was simple to extend the idea of a chameleon toy past a plushie. We figured we could create a chameleon toy that changes colors, and the method for changing colors would not be based on the surrounding environment, but be determined by a temperature sensor, effectively similar to a mood ring.

After deciding on a chameleon, we first looked for inspiration from existing chameleon plush toys. Our initial brainstorm included using SCAMPER.

SCAMPER analysis:

- Substitute
    - The external synthetic skin material can be replaced with cotton. The internal synthetic foam material could be replaced with authentic cotton for more plush. The insides can be fitted with LEDs for light-up colors.
- Combine
    - A microcontroller and temperature sensor can be combined to form the main selling feature of a “mood-ring” chameleon toy.

- Adapt
    - The chameleon toy could be used to educate about chameleon conservation efforts, and teach about the ecosystem.
- Minimize
    - The weird-looking eyes must be replaced with more adorable-looking eyes. The fact that chameleons change color must be emphasized.
- Eliminate
    - Remove the scaly-looking skin.
- Reverse / Rearrange
    - The general body shape must be rearranged into a cuter-looking appearance.

So far we had reasoned that both chameleon plushies and multi-colored plushies have been created. Yet, we were not discouraged, as we felt that Crayon would be the embodiment of a different premise brought to life. Crayon would be both a chameleon plushie and a multi-colored plushie, who would become the most adorable mood ring.

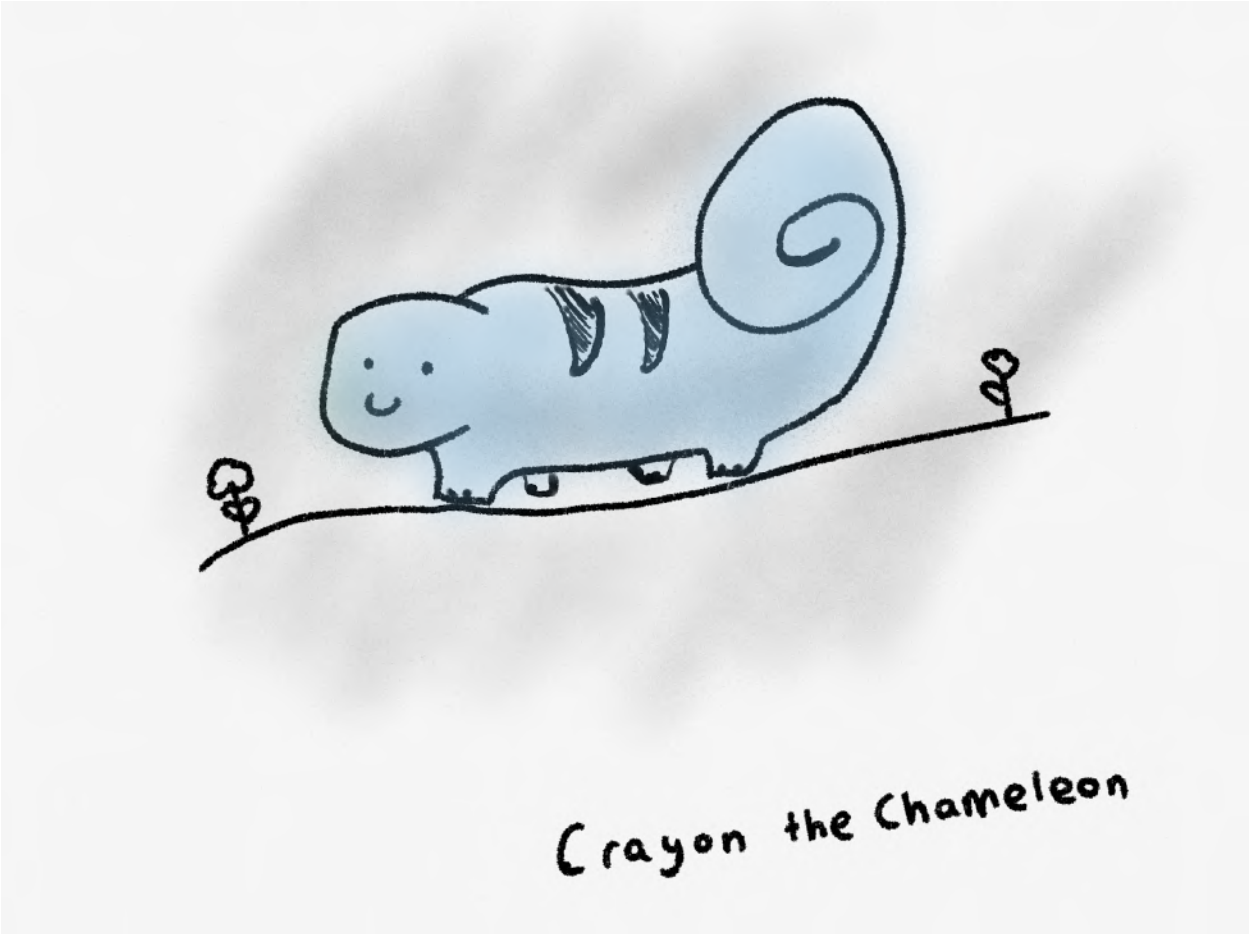
We had the option of using either a neopixel LED stick consisting of eight small multi-colored LED's, or an LED tape strip that is three feet long with multiple multi-colored LED's, which can be seen in the appendix. We used a decision making matrix to decide between the two alternatives.

Decision Making Matrix

Criteria	Weight	LED Tape Strip	LED stick
Flexibility	2	+	-
Adjustability	1	+	s
Number of LEDS	1	+	s
Robustness	2	-	+
Brightness	3	+	+

Clearly, the better alternative was the LED tape strip, as it provided features more suited to our needs. We would need flexibility since there is no guarantee that the product would not be bent during operation. The LED tape strip had significantly more LED's compared to the neopixel stick, which would be useful in case part of the LED strip was to break. As for brightness, both products performed well to our needs.

With these engineering requirements, customer requirements, benchmarks, and evaluations, we began to create the conceptual design for Crayon. The following picture shows our initial sketch for Crayon.



DESIGN FOR X

Crayon was design with various “design for X” possibilities.

Design for Manufacturing

Crayon was designed for mass production. As the bill of materials for the prototype shows, there is at most twelve components that went into making a prototype. These components added up to approximately $40 USD, which is below our customer requirement of $50.

Prototype Bill of Materials

Item	Part	Quantity	Name	Material	Source	Cost
1	Controller	1	Arduino Nano	Electronic Chip	Amazon	$10
2	LED	1	RGB LEDS	Glass/Plastic	Amazon	$15
3	Sensor	1	Temperature Sensor	Plastic	Amazon	0.01¢
4	Felt 1	1	White Felt – Right	Felt	Michaels	$3
5	Felt 2	1	White Felt – Left	Felt	Michaels	$3
6	Stuffing	1	Pellet Stuffing	Polyester	Michaels	$3
7	Zipper	1	Zipper	Plastic	Michaels	$2
8	Tongue	1	Tongue	Felt	Michaels	$1
9	Eyes	2	Chameleon Eyes	Plastic	Michaels	0.01¢
10	Stripes	5	Black Felt Stripes	Felt	Michaels	$1
11	Smile	1	Black Felt Smile	Felt	Michaels	$1
12	Legs	4	White Felt Legs	Felt	Michaels	$1

Knowing this list ahead of time would allow for faster manufacturing. However, the prototype bill of materials only represents the prototype. Designing for manufacturing can be taken further by using a bill of materials for mass production, where some parts may be removed or made more efficient to deliver a high quality product in a shorter period of time with minimum costs. The table below shows our estimated manufacturing Bill of Materials that features cut-down parts and estimated bulk-order pricing.

Manufacturing Bill Of Materials

Item	Part	Quantity	Name	Material	Source	Cost / Unit
1	Controller	1000	FPGA	Electronic Chip	Atmel	$5
2	LED	1000	RGB LEDS	Glass/Plastic	LED Supply	$5
3	Sensor	1000	Temperature Sensor	Plastic	Analog Devices	0.001¢
5	Felt	1000	Unibody Felt	Felt	S&S Worldwide	$3
6	Stuffing	1000	Pellet Stuffing	Polyester	S&S Worldwide	$1
7	Zipper	1000	Zipper	Plastic	IDEAL	$1

As the table shows, manufacturing in bulk with higher quality materials provides for a balance between quality and quantity. It would lead to an estimated price of about $15, which is much lower than the price for the prototype, and well within the customer requirement limit of $50 for a toy such as Crayon.

Designing For Safety

While making the prototype, we performed a Failure Modes and Effects Analysis. We discovered that the prototype had a few potential failure modes, but we believe they could be alleviated with stronger materials and better manufacturing practices during a manufacturing phase.

FEMA Analysis

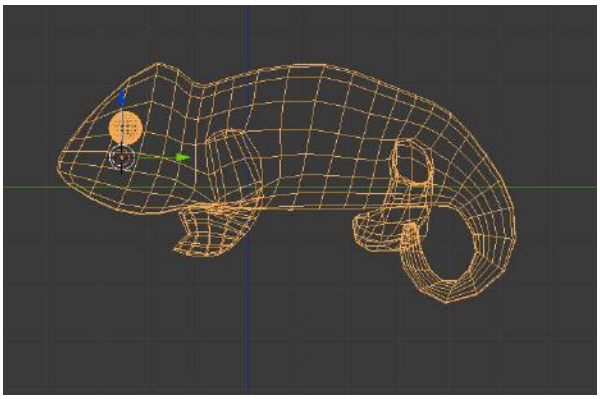
FEMA	Team D is for Design				
Product	Crayon the Chameleon				
#	Function Affected	Potential Failure Mode	Potential Failure Effects	Potential Causes of Failure	Recommended Actions
1	Wires are easily breakable	No signal to controller	No LED effects	Wire failure	Use stronger soldering and wires
2	Controller is easily breakable	No signal processor	No LED effects	Microprocessor failure	Enclose processor in shielding
3	Stuffing is flammable	Product may cause spark	Product may burn	Electrical spark	Insulate electronics
4	Sensor is easily breakable	No signal reading	No LED effects	Sensor failure	Protect sensor

Design for Sustainability and Society

Crayon was designed from the ground up with these concepts in mind.

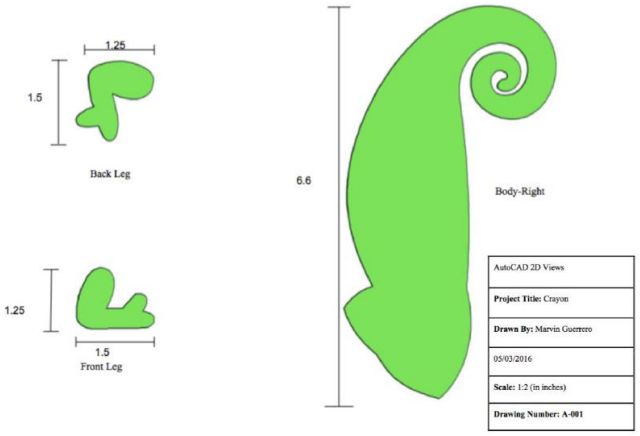
- Sustainability
    - Felt is biodegradable
    - Polyester fiber can be replaced with sustainably farmed organic cotton
    - Electronics and battery can be recycled
- Biological and Societal Concerns
    - Engages the conflict of an endangered species
    - Teaches children about the Reptilia Squamata Lacertilia class
- Medical
    - Shows an analogue measurement of temperature using lights
    - Children usually do not like medical tools so Crayon could be used to help with coping
        - Crayon could be made for higher accuracy readings
        - Crayon could be made for other applications such as arrhythmia sensing
    - An LCD could be attached for digital output readings
- Psychological
    - Crayon can substitute as an adorable night light
    - Helps with Nyctophobia - fear of the dark

PROTOTYPE & EVALUATION



We first began the prototype by sketching a design using CAD software. As the picture shows, the prototype was meant to resemble the general shape of a chameleon. We did not feel that rapid prototyping through 3D printing would produce a prototype adequate enough to our standards. Using 3D printing would result in a stiff, monocolor object with rough edges that vaguely resembles a chameleon. Printing the organic curves of a chameleon would be a challenge to represent through 3D printing.

We instead opted to create our own prototype by hand using arts and crafts methods. The design would be based off the AutoCAD drawing we had already prepared. The main body would be composed of felt fabric, while the inside would be stuffed with polyester to serve as cushioning for the delicate electronics. For more input, we conducted a survey to ask children questions about what they wanted in a toy.



Once the prototype design had been finalized, we began purchasing the necessary parts to build it. The most challenging aspect was sewing the outer layer together, as none of us had much experience with arts and crafts. The final prototype can be seen below.

Our product cost breakdown table can be seen below.

Product Cost Breakdown

	Fixed Cost	Var Cost	Mfg Cost	Total Costs	Selling Price
Direct Costs					
Material		✔	✔	✔	✔
Purchasing Parts		✔	✔	✔	✔
Labor		✔	✔	✔	✔
Tooling	✔				
Indirect Costs					
Overhead	✔		✔	✔	✔
Selling Expenses				✔	✔
Profit				✔	✔
Discount					

With this prototype, we concluded that:

- We would need a 5V and 3.3V power supply for the temperature sensor, LED's, and Arduino Nano. This could be handled by a 5V power supply and a voltage regulator.
- The most power consuming device is the Arduino Nano, which would take in about 2.5 mA of current.
- The length of the main body is about 17 cm.
- The dimension is about 17 cm x 7cm x 7 cm.
- A single 5V power supply was able to last about 6 hours of continuous use.
- The prototype design was very cute.
- The LED's used about 1 mA of current.
- We were satisfied with the brightness of the LED's.
- The main body protected the internals very well.
- The code responded very well to our customer demands.

For these reasons and others, we felt that our prototype successfully met the requirements.

CREATIVITY AND INNOVATION

We believe that everything that is core to Crayon is entirely new. There is no chameleon light up toy. There is no Chameleon toy that responds to temperature. There is no Chameleon toy that is adorable and shows the struggle that is the habitat conservation effort.

The most interesting idea is that this Chameleon toy actually changes color. Every chameleon toy we found was simply a caricature that was sewn with a single color. Using multi-colored LEDs to change color is an entirely new concept. It was very useful as well, because it allowed us to show multiple colors without significantly increasing the number of LEDs required. The chameleon concept blended well with this, because chameleons are known for changing their skin color to blend in with their surroundings. Finally, using the temperature sensor as the catalyst for changing colors was inspired by a mood ring. However, using a digital system allowed us to implement the concept with digital LEDs to replicate the same process.

What's innovative is the combination of several different factors, chameleons, biology, microprocessors, lights, and colors all into one cute package. What is important about Crayon is the concept behind using technology, cuteness, and biology to provide a bigger premise. Crayon has two purposes. One is to teach children about moods, temperature, and the endocrine system using a cute creature to soften the transition to this difficult concept. The other purpose is to educate about habitat conservation. We believe that Crayon could be changed to fit other needs, such as helping with nyctophobia, monitor other medical concerns such as arrhythmias, and potentially functioning as a heart rate monitoring system in a hospital without the need for direct sensors. Even more, the innovation behind Crayon is implementing cuteness

and monitoring systems to help children. For example, there could be a new product, a snail that holds onto a child's arm to monitor glucose.

CONTRIBUTION OF EACH TEAM MEMBER

Phiet Do

As the group leader of this project, I made sure we were meeting our goals. From creating a schedule, to addressing objectives, I provided the team with guidance and feedback on their work. I clarified any confusion and basically pushed the team to grow. In general, I created the power point, helped revise the report, was involved in directing the video, and finalized the prototype. I contributed to each of the aspects of this project and provided assistance whenever necessary.

I learned new concepts through the application of this project. I learned that it takes hard work and effort to not only come up with a design but also implement. One concept I thought was very useful was the construction of the Gantt chart. It provided a visualization of milestones and tasks so that my team and I were able to accomplish this project on time. Most importantly, without using the C-K theory, we wouldn't have come up with this amazing toy. Personally, I was struggling with brainstorming different toys. Using C-K theory, I was able to suggest ideas from different perspectives and fuse them together. I was able to grab fascinating knowledge from nature and incorporate it into a new product and generating ideas was easier than before. I enjoyed this project because it opened new tools I could use for designing other products in the future

Luis Perea

My position was second-in-command. I was mainly in charge of writing the report, and keeping up with a design journal. I also created the logo using Adobe Illustrator. I helped with building the prototype, and stepped in whenever our group leader was not available. I would manage the team at times to make sure everything was moving according to schedule.

I learned many things through this project. Mainly, I finally felt passionate about a project. No project I've done until now has actually made me smile, but Crayon is something different. I also learned that a good project is a lot of work. Writing a thirty-plus page report was a difficult task. Using the C-K theory was very helpful. Fusing ideas together was very helpful, as it allowed us to come up with several different ideas at once. Brainstorming is often the hardest and most important part of the project because it determines the entire direction the rest of the project will take. With this content, I will use C-K theory again in further projects. I learned about this by actually implementing the C-K theory in practice rather than just hearing about it through lecture.

Jeyanth John Britto

For this particular project, I was able to contribute to the research and implementation of our toy. In the research portion, I focused mainly on creating a survey or questionnaire about our toy. With the survey, we deemed how well our initial idea would do and how to change it up from the feedback from the survey. It also provided us with more information about what our customers are expecting from us. For the implementation part, I was heavily involved in the hardware and software implementation of the toy. There was a lot of testing and analyzing involved before I could get to a fully functioning prototype.

In addition to applying the information we were taught about design, I learned a lot of new concepts about design. The most interesting thing I learned was how the software development life cycle was really similar to the steps for design, which I thought was interesting. I learned a lot about making surveys and questionnaires: How to customize the questions to get the required information? The most important thing about the surveys were understanding the information. Another important concept I learned was C-K theory. Initially, the group had a hard time deciding on the project, but the C-K theory helped us combine different concepts into making our current product.

Marvin Guerrero

I definitely learned a lot of new concepts in this course, but it wasn't until I had to work on this project that I fully understood the importance of the concepts. My job for this group project was to do a 3D model of our design, I picked that task because I had no previous experience with that type of software and I thought it would be useful to learn how to use it. Because of my lack of experience with this type of software this proved to be a difficult task. At first I tried designing the model in AutoCAD but I was making no progress so I decided to use Blender. Blender proved to be relatively easier compared to AutoCAD.

Overall this project was definitely a new learning experience because it gave me insight on the real world and the process companies use to launch a new product. Also, it gave me first hand experience on the effort that it takes from all the team members to fully meet the expectations of the project. While working on this project we all required constant feedback from the rest of the team members. This was like the concurrent engineering that we had learned in class and it

proved to be more efficient for our needs. In conclusion, I had a fun time working with my team on a project like this.

Jay Patel

As the group videographer, I was in charge of making the video to show our work to everyone. I recorded the work of other teammates as they worked on their tasks so that I can use it for our video. I than compiled all the videos together showing the work done to make Crayon. I was also tasked with coming up with the cost analysis of the product and the bill of materials of Crayon to include it in our report and presentation slides.

This project helped me learn that it takes a team to make something successful. Working in team helps with coming up many different ways to solve a problem your team might be facing. I learned that there is lot of hard work involved from coming up with the design to launch of the product. One concept that helped was the C-K theory. C-K theory helped us come up the our toy Crayon. In beginning it was a struggle to think of a toy but using C-K theory helped us by allowing every group member's knowledge to be heard and fusing them together to come up with amazing ideas and deciding on the product. It was fun working on this project because it showed me tricks to use when designing and working on other projects in the future.

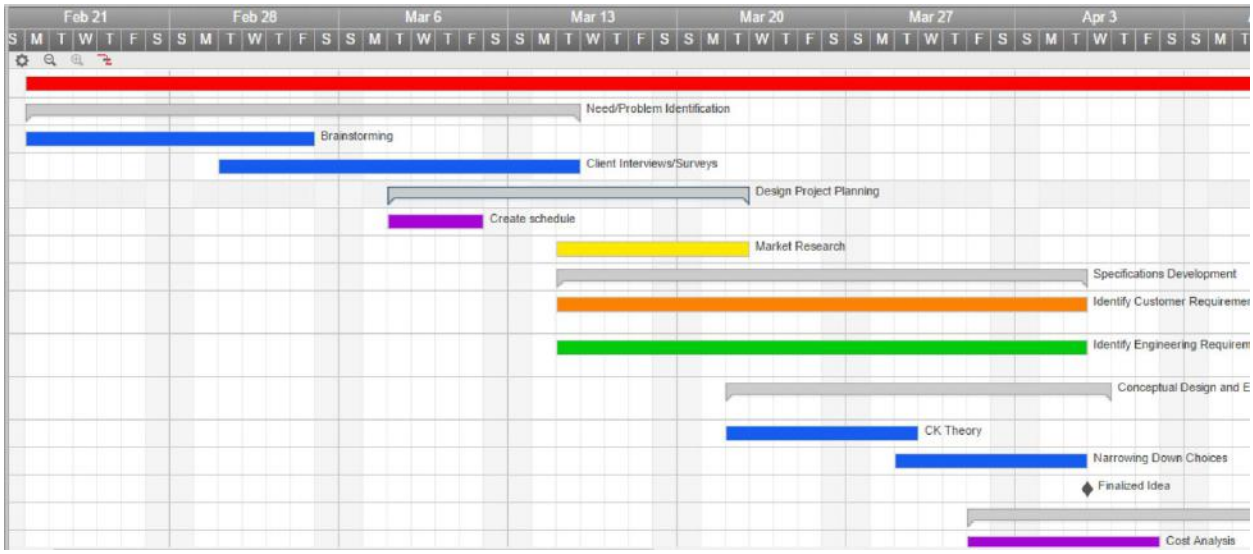
SUMMARY AND RECOMMENDATIONS

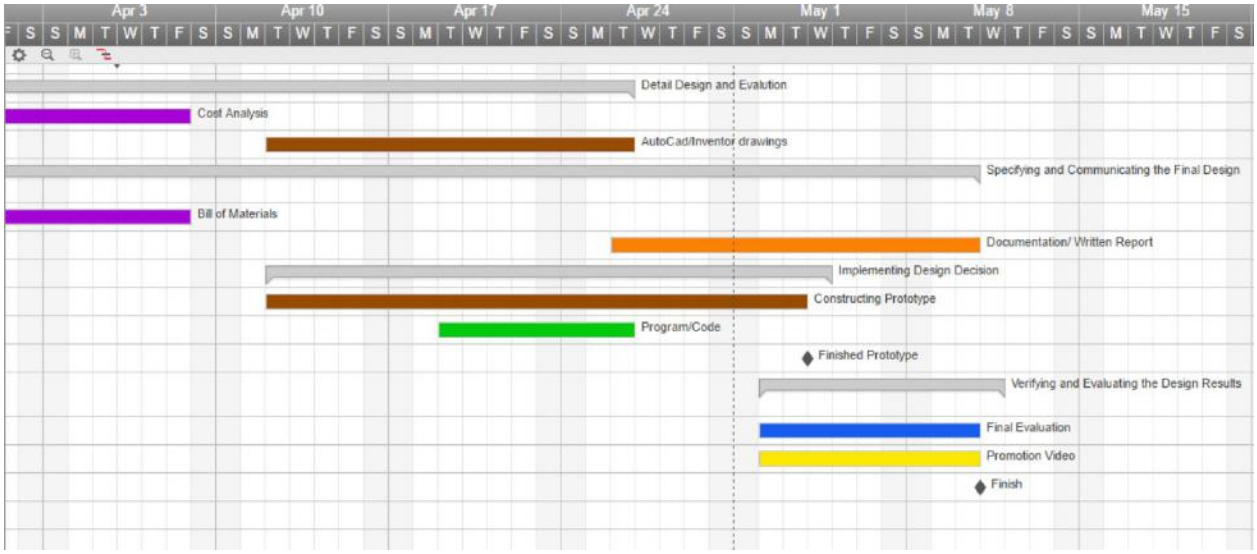
In the end, Crayon was our hopes and dreams colored into reality. Crayon was the combinations of nature, technology, cuteness, and efforts. Long ago, Crayon was nothing but an idea brought to us by the C-K theory. Crayon then began to form using CAD software, and was finally brought to life using arts and crafts. Crayon changes colors based on the temperature of

the user. 40°F or less is the default mode, and will shine different colors in a rainbow-mode. 40°F to 72°F would make Crayon shine white. 72°F to 74°F would be green. 74°F to 76°F would be cyan. 76°F to 78°F would be blue. 78°F to 80°F would be yellow. 80°F to 82°F would be red, and any temperature above 82°F would be magenta.

For recommendations, Crayon's felt body should be manufactured using a uni-body fabric structure. This would allow Crayon to be more robust while maintaining his appearance and cutting costs. Crayon's internals should be made of fire-retardant polyester or static-resistant foam to reduce the risk of an electrical spark or shock. Crayon's features should be expanded, as with other sensors, he could potentially replace a heart rate monitor, and show a child their heart rate by flashing in rhythm with a heart beat. Crayon should also come with a pamphlet explaining the plight of the chameleon, and should star in his own tv show or novel series to spread the word of Crayon.

APPENDIX


Feb 21
Feb 28
Mar 6
Mar 13
Mar 20
Mar 27
Apr 3
Need/Problem Identification
Brainstorming
Client Interviews/Surveys
Design Project Planning
Create schedule
Market Research
Specifications Development
Identify Customer Requiremer
Identify Engineering Requirem
Conceptual Design and E
CK Theory
Narrowing Down Choices
Finalized Idea
Cost Analysis


Apr 3
Apr 10
Apr 17
Apr 24
May 1
May 8
May 15
Detail Design and Evalution
Cost Analysis
AutoCad/Inventor drawings
Specifying and Communicating the Final Design
Bill of Materials
Documentation/ Written Report
Implementing Design Decision
Constructing Prototype
Program/Code
Finished Prototype
Verifying and Evaluating the Design Results
Final Evaluation
Promotion Video
Finish

Neopixel LED stick

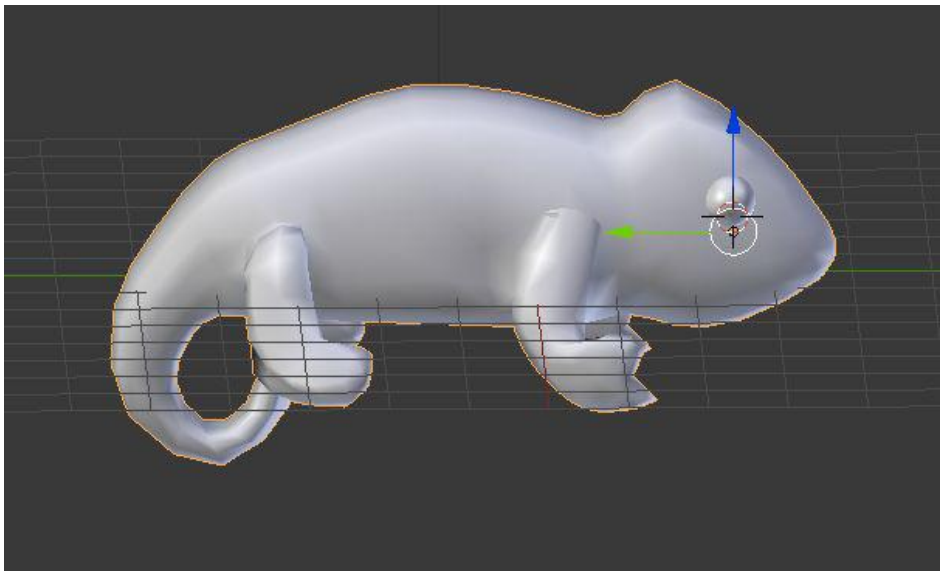
3 ft. long LED strip

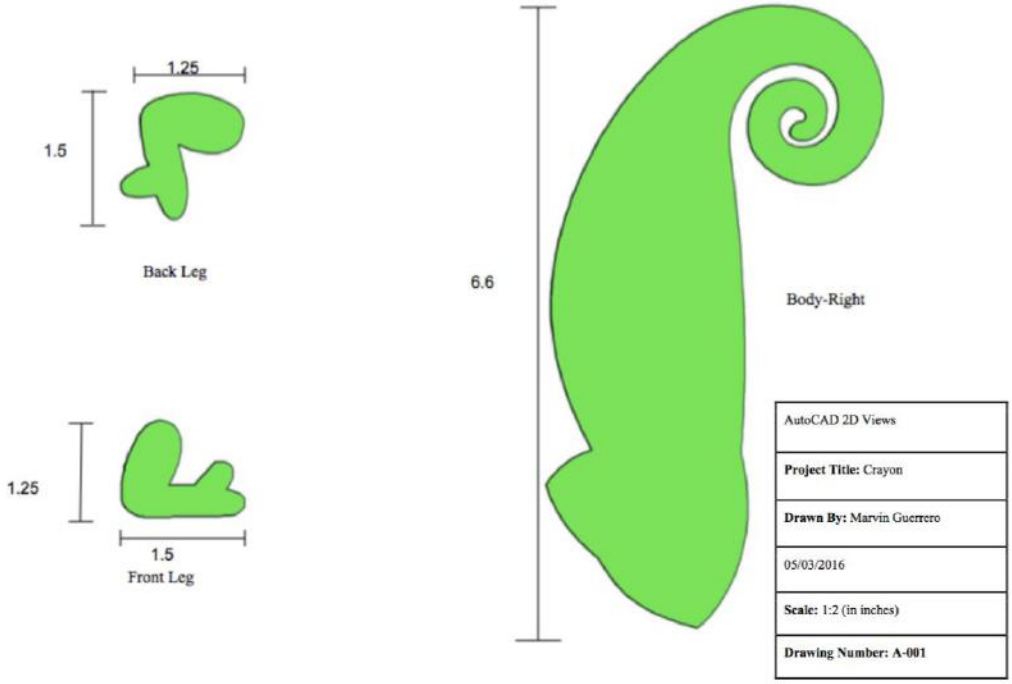
```
#include <Adafruit_NeoPixel.h>

#define PIN 6

Adafruit_NeoPixel strip = Adafruit_NeoPixel(60, PIN, NEO_GRB + NEO_KHZ800);


int sensorPin = 0; //the analog pin the TMP36's Vout (sense) pin is connected to
                        //the resolution is 10 mV / degree centigrade with a
                        //500 mV offset to allow for negative temperatures

void setup() {
  // put your setup code here, to run once:
  strip.begin();
  strip.show(); // Initialize all pixels to 'off'
  Serial.begin(9600);
}

void loop() {
  // put your main code here, to run repeatedly:

  float temp = getVoltage(sensorPin); //getting the voltage reading from the temperature sensor
  temp = (((temp-0.5)*100)*1.8)+32;
  int tempF = temp; //to degrees ((volatge - 500mV) times 100)
  Serial.println(tempF); //printing the result
  Serial.println(temp);
//  int reading = analogRead(sensorPin);
//  float voltage = reading * 5.0;



delay(3000);

if(tempF<40)//default
{
  Serial.println("Rainbow");
  rainbow(20);
}
else if(tempF<=72)
{
  Serial.println("White");
  colorWipe(strip.Color(255, 255, 255), 50); // White RGBW
}
else if(tempF<=74)
{
  Serial.println("Green");
  colorWipe(strip.Color(0, 255, 0), 50); // Green not under stress
}
else if(tempF<=76)
{
  Serial.println("Cyan");
  colorWipe(strip.Color(0, 255, 255), 50); // cyan relaxed
}
else if(tempF<=78)
{
  Serial.println("Blue");
  colorWipe(strip.Color(0, 0, 255), 50); // Blue normal
}
```

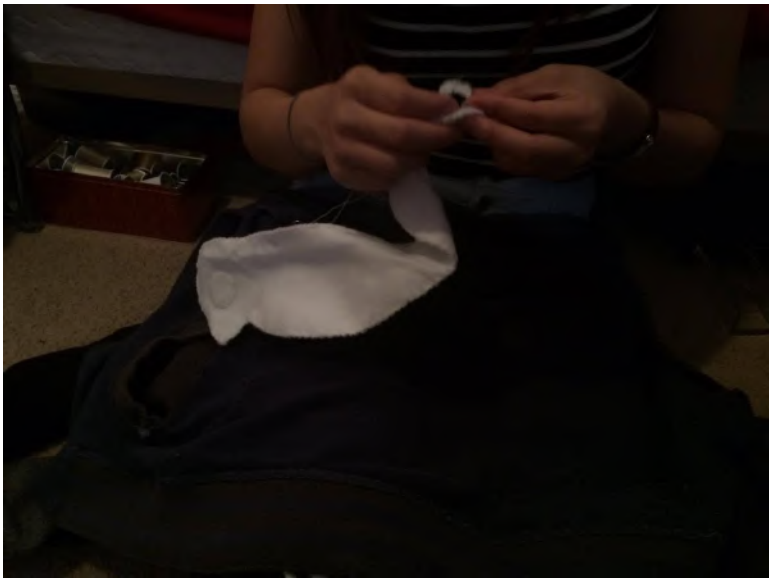
```
    {
      Serial.println("Yellow");
      colorWipe(strip.Color(255, 255, 0), 50); // Yellow unsettling
    }
    else if(tempF>=82)
    {
      Serial.println("Red");
        colorWipe(strip.Color(255, 0, 0), 50); // Red nervous
    }
    else
    {
      Serial.println("Magenta");
      colorWipe(strip.Color(255, 0, 255), 50); // Magenta stressed
    }


  }

  void colorWipe(uint32_t c, uint8_t wait) {
    for(uint16_t i=0; i<strip.numPixels(); i++) {
      strip.setPixelColor(i, c);
      strip.show();
      delay(wait);
    }
  }
```

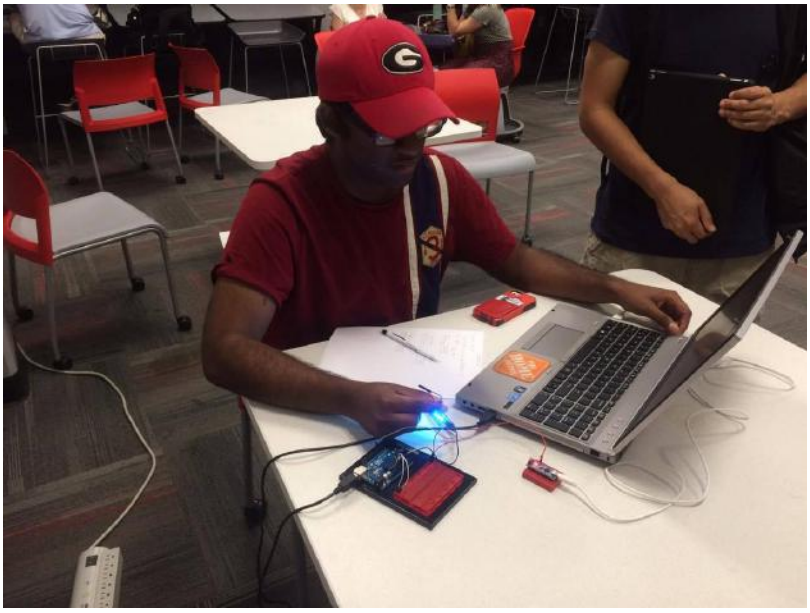
```
// Slightly different, this makes the rainbow equally distributed throughout
void rainbowCycle(uint8_t wait) {
  uint16_t i, j;

  for(j=0; j<256*5; j++) { // 5 cycles of all colors on wheel
    for(i=0; i< strip.numPixels(); i++) {
      strip.setPixelColor(i, Wheel(((i * 256 / strip.numPixels()) + j) & 255));
    }
    strip.show();
    delay(wait);
  }
}

float getVoltage(int pin){
return (analogRead(pin) * .004882814); //converting from a 0 to 1024 digital range
// to 0 to 5 volts (each 1 reading equals ~ 5 millivolts
}

void rainbow(uint8_t wait) {
  uint16_t i, j;

  for(j=0; j<256; j++) {
    for(i=0; i<strip.numPixels(); i++) {
      strip.setPixelColor(i, Wheel((i+j) & 255));
    }
    strip.show();
    delay(wait);
```

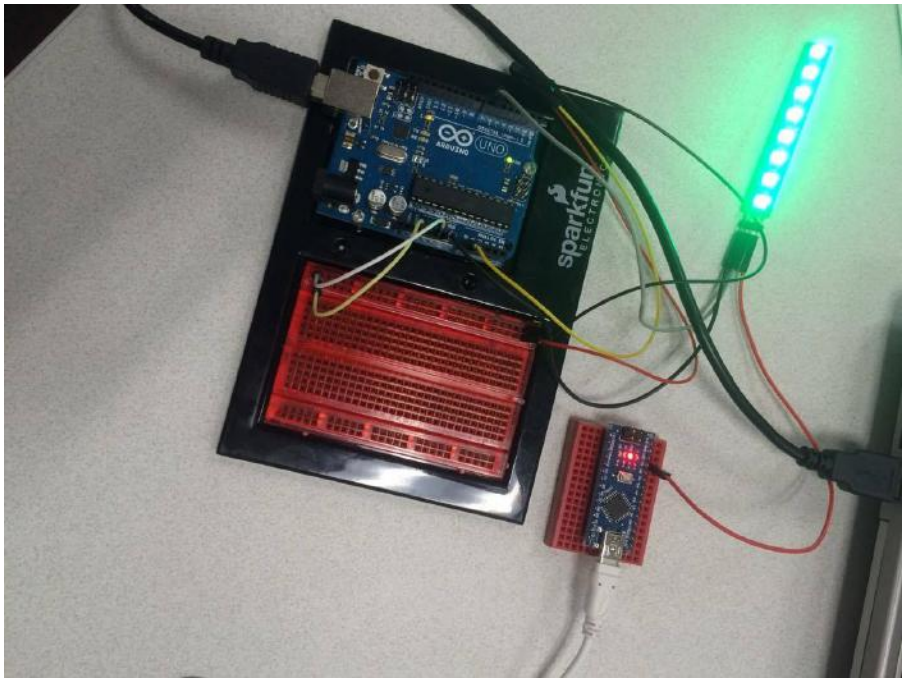
```
void rainbow(uint8_t wait) {
  uint16_t i, j;

  for(j=0; j<256; j++) {
    for(i=0; i<strip.numPixels(); i++) {
      strip.setPixelColor(i, Wheel((i+j) & 255));
    }
    strip.show();
    delay(wait);
  }
}

uint32_t Wheel(byte WheelPos) {
  WheelPos = 255 - WheelPos;
  if(WheelPos < 85) {
    return strip.Color(255 - WheelPos * 3, 0, WheelPos * 3);
  }
  if(WheelPos < 170) {
    WheelPos -= 85;
    return strip.Color(0, WheelPos * 3, 255 - WheelPos * 3);
  }
  WheelPos -= 170;
  return strip.Color(WheelPos * 3, 255 - WheelPos * 3, 0);
}
```

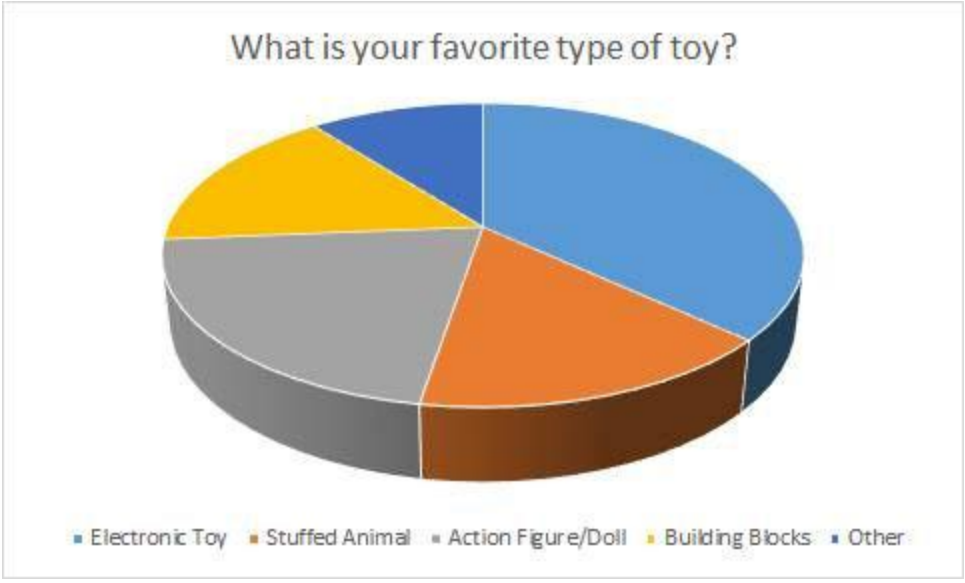



1.25
1.5
Back Leg
1.25
1.5
Front Leg
6.6
Body-Right
AutoCAD 2D Views
Project Title: Crayon
Drawn By: Marvin Guerrero
05/03/2016
Scale: 1:2 (in inches)
Drawing Number: A-001








What is your favorite type of toy?
Electronic Toy
Stuffed Animal
Action Figure/Doll
Building Blocks
Other

TEAM D IS FOR DESIGN

Phiet Do
Team Leader - Pokemon Master

As team leader, Phiet organized the team, sewed Crayon the Chameleon, purchased all materials, delegated tasks to other team members, and oversaw the design process from start to finish.

Luis Perea
Co-Founder - CEO

As CEO, Luis helped in the creation of Crayon and supervised the product realization of Crayon. He also was in charge of writing the report which is regarded as the most important task.

Jey John Britto
Designer - Lead Programmer

As lead programmer, Jey was in charge of implementing the core experience of Crayon. Without Jey, Crayon would not have become gooder than the best.

Marvin Guerrero
Intern - Lead Prototype Expert Engineer

As lead prototype expert engineer, Marvin was in charge of rapid prototyping of Crayon. He also hid Luis's pencil.

Jay Patel
Designer - Lead Principal Photography Photographer

As lead principal photography photographer, Jay was in charge of principal photography. He was tasked with creating the best marketing tactics and videos to convey the emotion that is Crayon.

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