Manufacturing Process Design

UNO USB LAMP

06-92-440/06-91-321

Submitted to: Dr. Jill Urbanic

By:

Samer AlShaibani (Leader) [redacted]
[redacted] ______________________________

Ajwad Ishaque [redacted]
[redacted] ______________________________

Mohammed Gouda [redacted]
[redacted] ______________________________

Mohamed AlAmoudi [redacted]
[redacted] ______________________________

Submitted:

12/8/2015

Abstract

This report illustrates not only the fundamentals and concepts that were put into place in order to fabricate the project, but demonstrate the necessary steps that were taken to achieve two working models. Various approaches, applications, methodologies, FEA analyses and simulations were conducted in order to achieve success. The objective of this project was to fabricate and modify a USB-Lamp accordingly from a given instruct-able template. The following are the guidelines that were listed for this project:

- Must use multiple manufacturing processes
- Design related calculations must be done to support your design decision making
- Must create molds with minimal silicone usage
- Wall thickness of mold minimum 3 mm
- You must calculate the amount of resin and molding material required
- This includes pre-determining the ratios for the materials
- Minimum two joining methods must be utilized
- Minimum and maximum component thickness to be justified
- You can design for X and modify the geometry for joining or to provide economies of scale advantages
- The design for X related decision making must be discussed in the report

With the help of various design tools, effective and efficient project management and competitive manufacturing, assembly and finishing processes, the USB-Lamps were made.

Table of Contents

List of Figures

List of Tables

1.0 Introduction

The definition of Manufacturing is to make something on a large scale with the use of machinery, molds and other various methods. It can be paraphrased also as a process of converting raw materials into a product that satisfies the customer needs. The key aspects of this include the design, how it was made and how it was assembled. There are several consistencies between different types of manufacturing processes. Understanding these is very important as it allows us to keep up to date with products who are constantly evolving in today's world. In this project a combination of these manufacturing processes were used; ranging from CNC, Rapid Prototyping, Casting, Soldering along with several others in order to meet the groups requirements.

The template provided to the group was not accurate and needed to be modified such that a typical USB would fit on its inside stand mechanism. This was a very crucial step that the group had to make as it would ensure that parts fit properly. By using a simple ratio of provided/actual dimensions, the group was able to determine how much the drawing was scaled as illustrated below:

Hence from the figure above the scale was determined to be 10.64% greater than what it

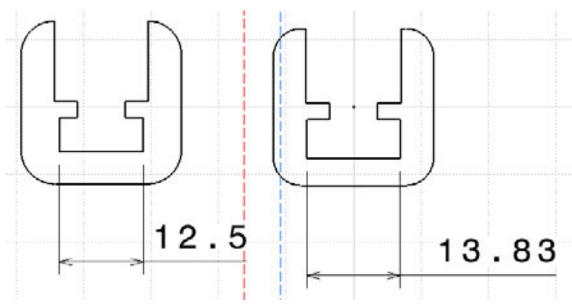


Figure 1 Illustrates the actual (left) and provided (right) USB holders

should have been and all of the necessary adjustments to the design were made accordingly. Several parts were modified.

2.0 Objectives

2.1 Design

For a successful product, proper planning is always needed. The release of our new product involved multiple steps that were taken before its launch. The breakdown of the steps were parts, processes designs, calculations and fabrication.

<u>Design Phase:</u>

When we came to design our product we sat and started brainstorming and drew some preliminary drawings. We came to a conclusion that our designing phase should be delivered with the below points in consideration:

- Functionality: The product must function properly for intended purpose.
- Reliability: The product must perform properly for the designated period of time.
- Productivity: The product must be produced with a required quantity and quality at a defined and feasible cost.

As well during the designing phase we had to perform calculations in order to optimize the manufacturing phase as well to decide on the best materials required for the product. The material selection was based on multiple requirements. Of these important requirements:

- It satisfies the technical, safety and legal requirements.
- It is economical thus could be sold at a competitive price and to dispose it satisfactorily at the end of its useful time.
- It is highly recommended to use materials those are recyclable and biodegradable in order to make sure that they will help to minimize the production of waste.

With all these points considered our design was to be as efficient as possible and to reduce the effect on the environment. Meanwhile should be durable and reliable for the consumer to trust and use while not forgetting the purpose of the product, as well the aesthetics of the design.

2.2 Project Management

Our client for this project was requesting to have the product ready by Monday, December 7, 15 and we were given this project a month ago. As our company dynamics we must have a workshop meeting where sat down to brainstorm as well to split job tasks. The project was divided onto as follows:

CEO Samer AlShaibani:

- Head of UNO company,
- Ensures tasks are divided on each team member
- Contributes with his own share of the work

VP Technical Ajwad Ishaque

- Modifies drawings
- Responsible for all electrical work including arduino and all programming stuff

VP Project Mohammed Gouda

- Brainstorm Ideas
- Design parts

VP Manufacturing Mohamed AlAmoudi

- Responsible for manufacturing the parts
- Assembling the parts

In order to meet our deadline we came with a Gantt chart to follow:

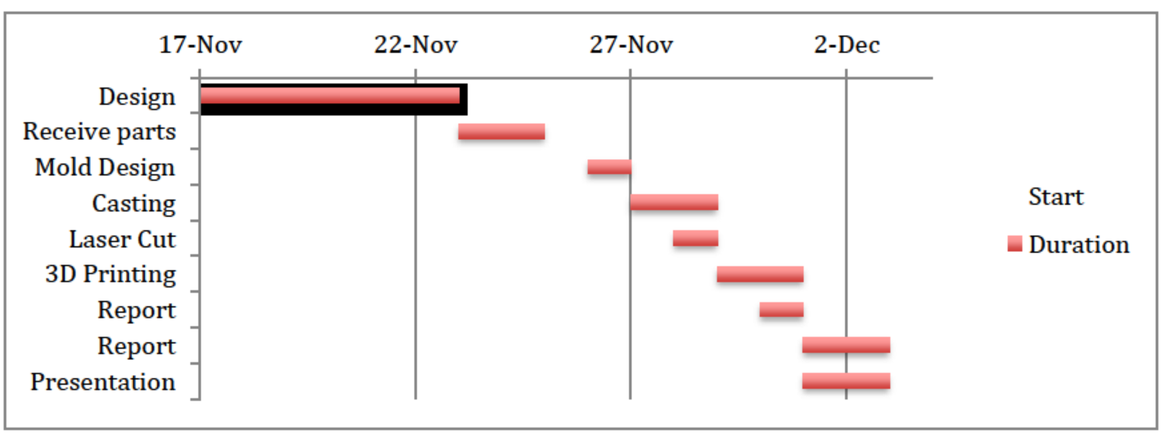


Figure 2 Gantt Chart

3.0 Approach and Methods

3.1 Manufacturing approach

Manufacturing is inventing or fabricating a product using different materials and manufacturing processes. Different manufacturing processes leads to different conclusions. Group 1 used several methods to manufacture the most efficient, safe, and stable USB Lamp. These methods were explained and taught verbosely to ensure safety to all students. The first manufacturing process which was the easiest is called **Casting**. Casting is a popular manufacturing process that involves liquid pouring into a mold that contains the determined shape of the product. The liquid poured was a combination of two different materials at a ratio of 1:1. In comparison with other manufacturing processes used in this project, casting was the most hectic. On the other hand, the results were phenomenal. The product was removed from the mold smoothly without any damages. The drying time was fast and the product was firm, strong and ready to be used. This process is also way cheaper than the other manufacturing processes used.

Figure 3 Casting Result

The second Process used to manufacture the USB Lamp was **Rapid Prototyping**. Rapid prototyping uses a unique technique to print the designed part using a 3D printer. This process is pretty easy too, but not everyone can use it. It needs a well-educated engineer specialized particularly in CAD programs to design the part before printing it. Several parts of the USB Lamp were designed and manufactured using a 3D printer. Both the base and the diffuser supporter were designed by using Catia v5 and printed perfectly.

This process has great advantages such as:

1. Saving Cost and Time
2. Production of Complex Designs
3. Strong and Durable Material

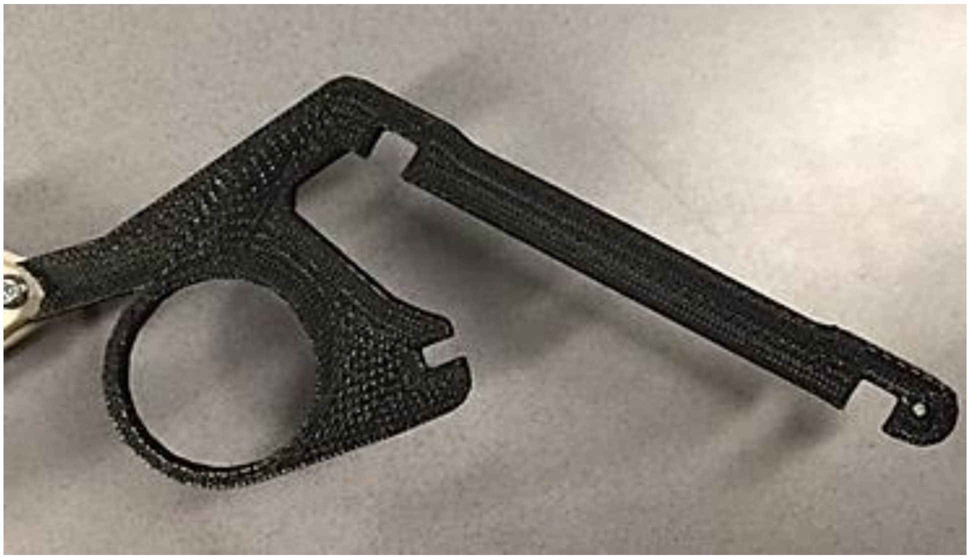


Figure 4 3D Printing Result

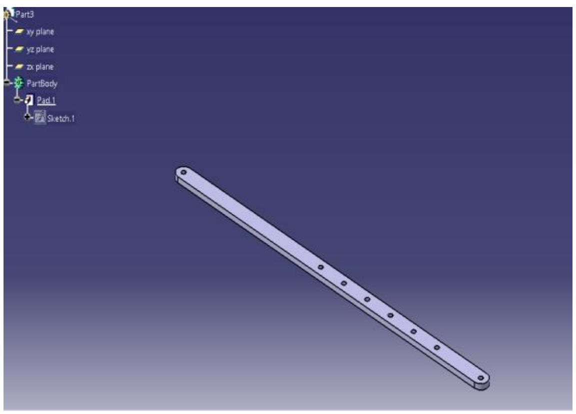
The third and final manufacturing process that was used by group 1 is **CNC Machining**. It is 100% computer controlled cutting machine. It is usually used to cut hard material such as aluminum, steel, wood, etc. Group 1 as usual is always thinking outside the box, so we designed a part and manufactured it by using CNC machine. The result was fantastic. It took the controlled machine 18:33 to produce a perfectly smooth and powerful part. The only problem was that part was heavy due to the used material (Stainless Steel).

Figure 5 CNC Result

3.2 Assembly and Finishing Approach

After all parts are manufactured using all processes mentioned above, the assembly process starts. It is when all parts are put together in order to form a product which is the USB Lamp. Several fitting such as bolts and nuts are the main parts in this process. These fittings help combine all parts together and ensure a tight fit for the final product.

The Lamp contains five designed arms with specific measurements to accomplish a particular task. Two of the five arms are design to maintain stability. Both arms have two holes drilled and threaded with a diameter of 2.5mm. These holes are located at the far end of both arms to connect the arms with other parts of the lamp. The remaining three arms contain six holes other than the ones at each end which is a total of 8 drilled holes. All holes have the same diameter. These six holes are intended to control the angle and height of the lamp according to the user.



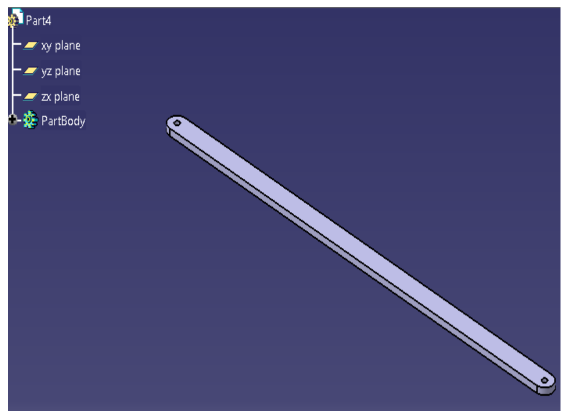


Figure 6 Arms

Every part has a specific amount of stress endurance that can be calculated using Von mises stress analysis. A 300N distributed load is been applied at the middle of the arm to determine the amount of stress that it can tolerate. Once the force is applied, the arm is being deformed causing it to bend. The highest amount of stress that the arm can tolerate is 2.3x10^6N/m^2. However, the translation displacement vector can also be calculated using the same method (von mises). The highest displacement occurred at the middle of the arm which is 1.01mm.

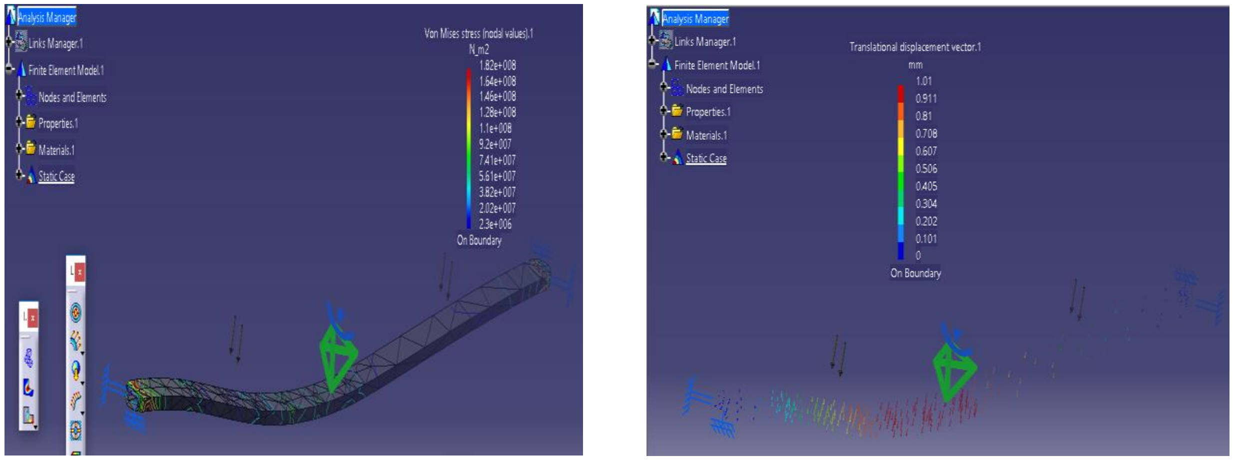


Figure 7 Stress & Displacement Result

The height of these arms is designed in a way that is **not** too high from the laptops keyboard and **not** too low that it might block the vision of the user. They have an efficient height of 200mm and a thickness of 3mm. With these measurements, a light weighted arm is being manufactured which is one of the main goals to be achieved.

Each user will have the ability to control and adjust the height of the lamp as well as the angle of light using simple machine screws/nuts and a rubber band. The screws are designed to fit perfectly between the holes provided in the stand parts. This will insure stability in different heights. However, the rubber bands are used to regulate the angle of light.

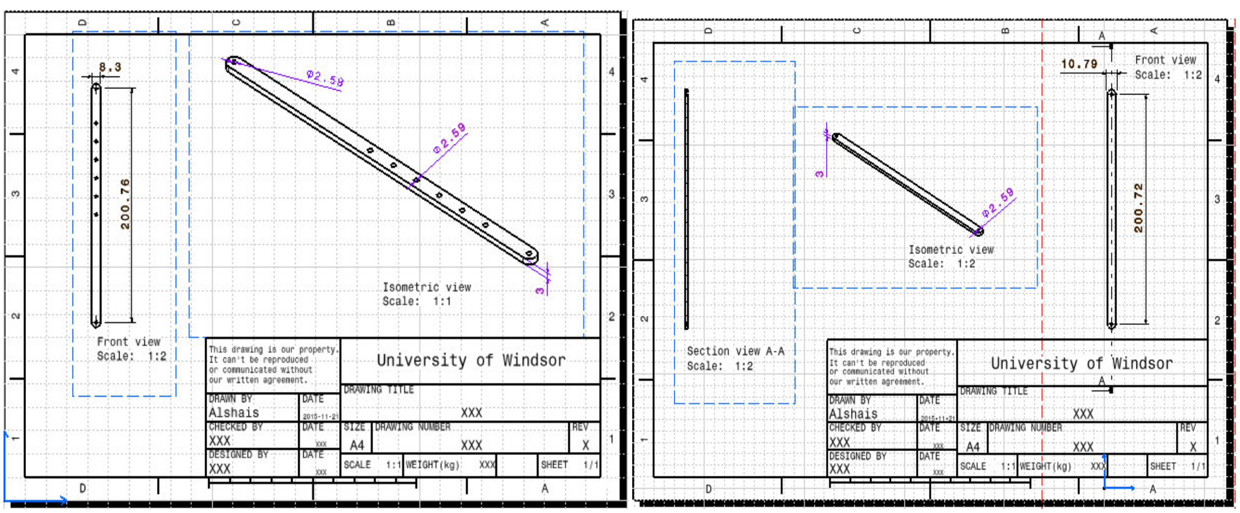


Figure 8 Drafting CAD Designs

Diffuser Holder

The diffuser holder was made by using three different materials to analyse the strength and compare it capabilities. The first one was made by using Alumilite. It was efficient but didn't have the durability of both the stainless steel and 3D printing part. Some heat might be applied by the bulb that will rise the temperature of the surrounding parts. If too much heat is applied on the Alumilite part, it will cause the part to shrink which will lead to further problems. By using Catia v5 we estimated the highest amount of heat the part can handle until before it shrinks.

Screw drivers will apply pressure on the part while screwing the bolts and nuts. So a von misses stress analysis was determined. The highest pressure the part can handle is 4.34e+0.008N_m2 which are capable of ensuring safety.

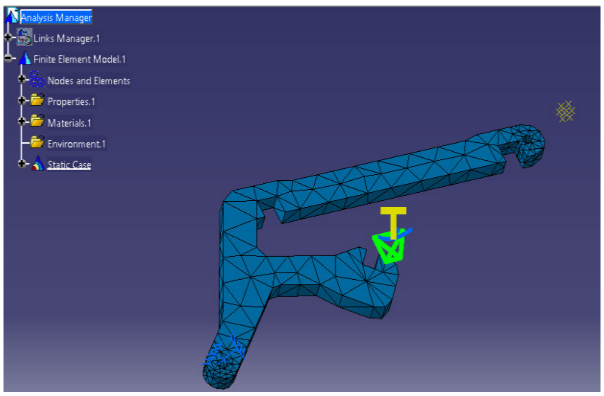


Figure 9 Temperature Analysis

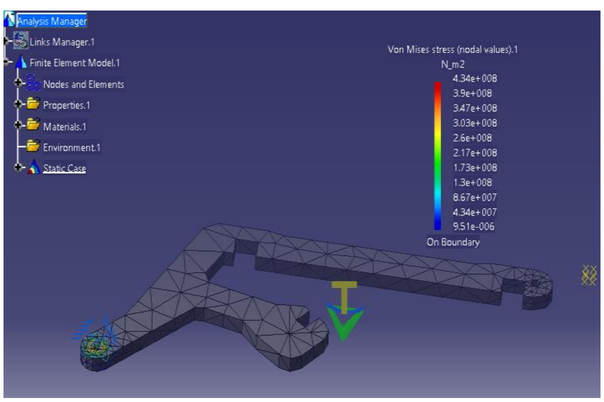


Figure 10 Stress Analysis

3D Printing design

Rapid prototyping was a great advantage to this project due to the great parts it can manufacture. One of the three diffuser holders was made up of filament. Different pressure, stress, and temperature analysis was applied on it to minimize all errors. This holder had a different design. It contained a hole with a diameter of 27mm that holds a fan in place. This design is made for the convenience of Uno companies customers. The fan has a 3 volts power that allows it to give a suitable circulation of air to the user. The figure below illustrates the CAD design of the new holder.

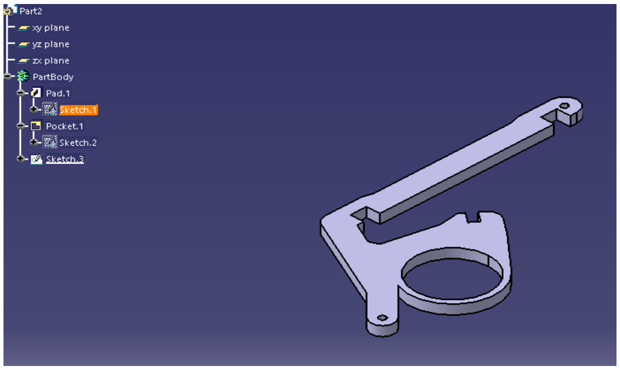


Figure 11 Catia Drawn Part

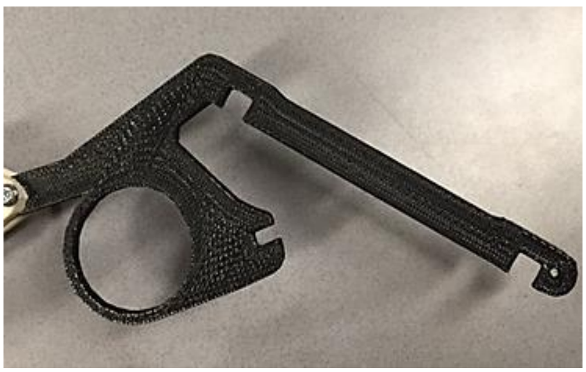


Figure 12 Actual Part

The same FEA analysis is done to the 3D diffuser holder to guarantee the perfect result and product. In this simulation, one of the drilled holes was clamped to hold the part in place which is basically the part that is attached to the arms and the triangle. Pressure was applied in thepther end and distributed force was applied with 100N in the Y-axis direction which is basically going down. This caused the holder to bend forward due to the force applied. The results are shown in the figure below.

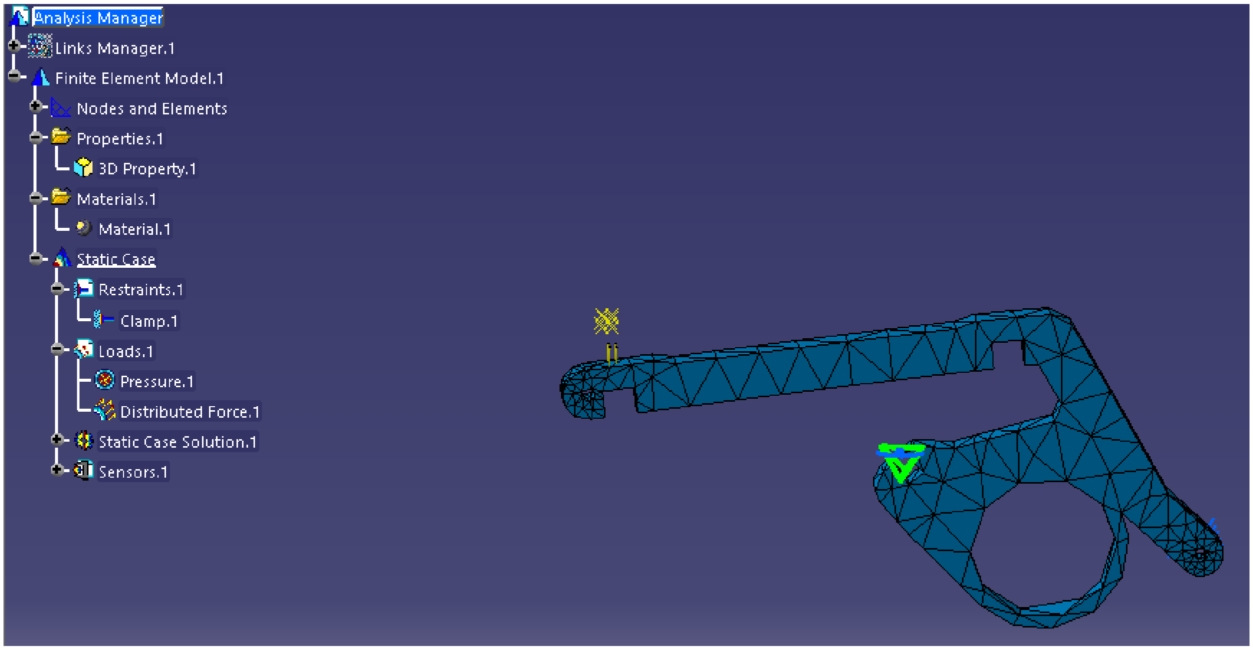


Figure 13 Bend due to applied force

Base Design

The old base was made up of a U-Shaped part that is assembled together. Group 1 Managed to think outside the box and change the design of both models. Model X which is the first model has a Green base made up of filament by using the rapid prototyping processes. It contains a hole that gives the lamp the freedom of motion. It covers a 360 degree to cover most surrounded areas with light. However model Y has the same material and is made by the same printer but has a completely different design. It is a cubic shape with a 60mm width and a 90mm hight. This space is made to fit the arduino base and all cables that will light up the lamp.

Material Research and Selection

All parts were cut by using the University of Windsor machine shop. After all parts were ready, they were placed inside a cardboard box to form a mold. The mold was made up of **Silicone** that was provided by the University of Windsor.

Using different materials leads to different results in strength, durability, and quality. Therefore, before building the USB Lamp, Group 1 did a tremendous amount of effort in researching materials that can be used for this project. As a result, the USB Lamp was a combination of three materials. The first material which was mandatory for all students is

Alumilite. It is the liquid material that is poured in to the mold and used in the casting process. Alumilite has great advantages that were determined after experiencing it. It has high strength, smooth surfaces, and after our great research we determined that it is resistant to corrosion.

The second material used was **Stainless Steel.** This material has large tolerance to rust and tarnishing. Stainless Steel is pretty strong and has high tolerance of heat which might be applied by the bulb. It is also a poor conductor of heat which makes it safer than other metals. On the other hand, steel is heavier that other material used. In comparison with the other parts, stainless steel is double the weight. Therefore, only one part out of the thirteen parts is made up of stainless steel.

The third and last material used was **Polyactic Acid** (PLA) for the 3D printing part. It is one of the most commen material used for 3d printing. PLA is useful in broad range of printing application and has the virtue of being both odourless and low-warp. It creates a high tolerance product with a unique surface. It comes with different colors that can make your final product more pleasing and colourful.

<u>Machining Approach</u>

Finalizing the parts were done by using the University of Windsor's work shop machines. Three machines were used by Group 1 to produce a pleasant shape for each part. The first machine and the most used one is the **Grinding Machine.** It is used to create a smoother surface and level up the part.

The second approach used to finalize the parts was the **Drilling Machine**. Holes were drilled according to the measurements made in the CAD design. All holes had to be aligned together to fit perfectly and eliminate any offset angle errors. Eliminating all errors while machinig was a challenged to Group 1 due to lack of experience in that field. However, with the help of Andrew Jenner the head of the work shop, all students climbed all barriers.

The holes definitions were designed before the machining process to ensure a perfect fit. All extension, types, and thread definitions are taken into consideration by using CAD programs. The treading type was applied as simple to minimize any complications. Although, the threading type was chosen as Metric Thick Pitch and the description is M4.

In the figure below, a cross section was applied on the front view. The triangle section view was an example of all holes in the model. It shows the threaded lines, centre line, and hidden lines in the part. This technique was used for all parts that contain holes.

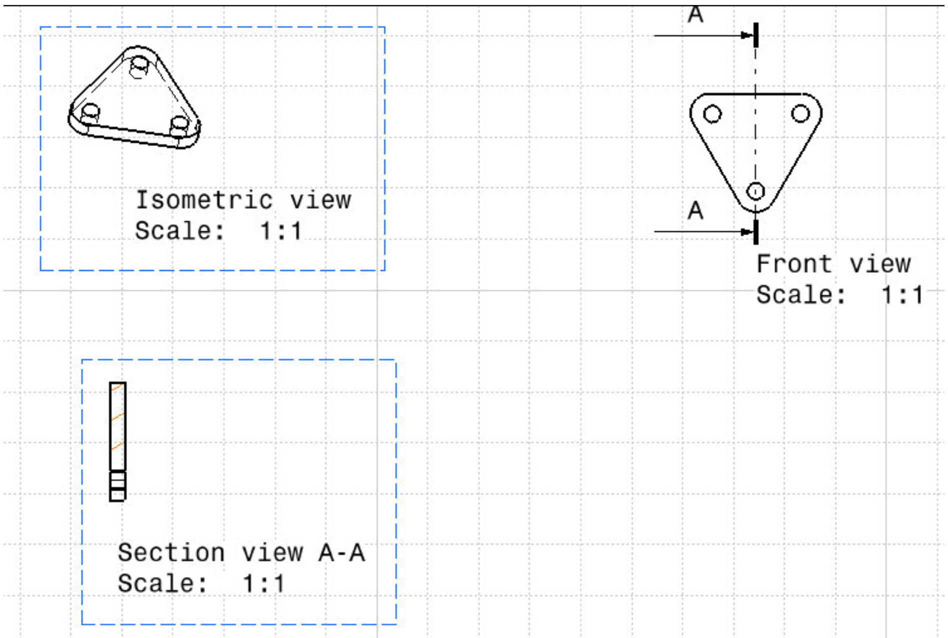


Figure 14 Triangles Views

3.3 Project Overview & Bill of Materials

Table 1 Overview Plan

	Part Description	Process	Duration	Materials
1	Print out of parts 1:1 Scale	Printing	20 minutes	Paper
2	Cut out parts	Cutting	1 day	Wood
3	Mold Design	Molding	1 day	Silicon/Cardboard
4	Parts	Casting	1 day	Alumilite
5	CNC Machining	CNC	18 minutes	Stainless Steel
6	3D printing parts	Rapid Prototyping	1 day	Filament
7	Sanding parts and trimming	Surface finishing	1 day	Sand Paper
8	Drilling holes	Drilling	1 hour	UWindsor resources
9	Putting parts together	Parts Assembly	1 day	Tools
10	Creating Arduino circuit	Electrical Work	3 days	Arduino Kit

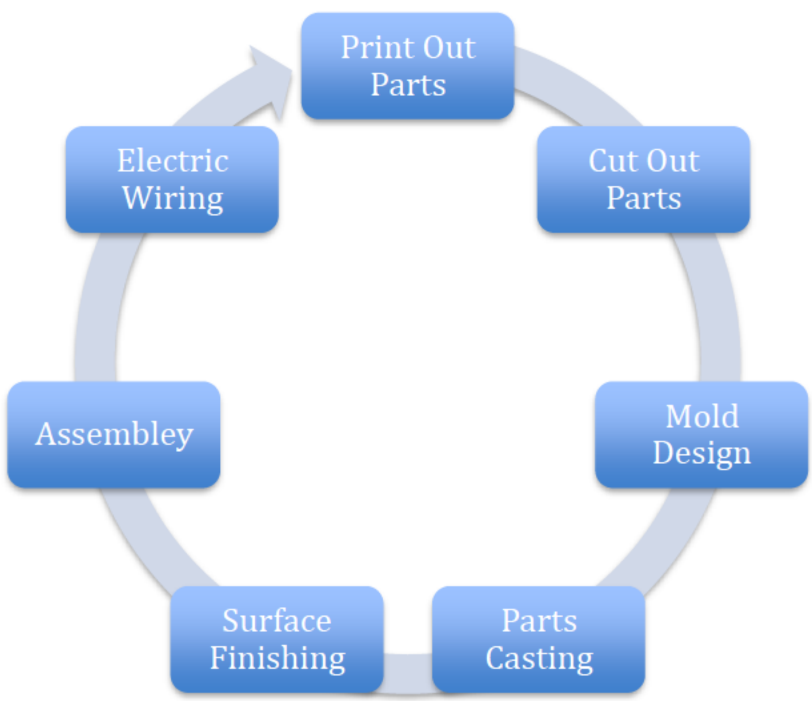


Figure 15 Overview Plan

Table 2 BOM

Material	**Quantity**	**Reason**
Alumilite Regular 2 gal. Kit Tan - Component material	1	Casting
QuickSet 10 lb. Tan	1	Casting
Measuring cups	5	Casting
Stir sticks	1 pack	Casting
Corrugated Plastic Strips	1 pack	Casting
Rubber to Rubber Mold Release	1	Molding
Modeling clay	1	Molding
Stainles Steel	7"x7"x1/8	CNC
Filament	250grams	3D Printing
Good super glue	1	Assmbley
Wire cutter	1	Assmbley
Arduino Kit	1	Assmbley

3.6 Volume Calculation

As mechanical engineering students we are taught to use Catia V5 which is a multiplatform CAD commercial software that assembles and analyses parts [3]. Through our knowledge in Catia, we firstly drew each part based of the drawing we were given. As we reached the assembly phase we realized that not all the parts were dimensioned to fit in. We went back to our workbench and modified our parts. As well we performed analysis on each part to ensure that it would withstand all the forces applied to it. Through these analysis it was then clear to us the materials to be used based on mechanical properties such as modulus of elasticity and yield points. With all our parts drawn out it was accessible to us to calculate the volume of each part and the whole product, which would help us to optimize the materials we would be using in the manufacturing phase.

Table 3 Parts Volume

Quantity	Part Name	Part Number	Individual Volume (M^3)	Actual Volume (M^3)
2	USB Holder non Rounder	1	9.03E-07	1.81E-06
3	USB Holder Rounded	2	8.54E-07	2.56E-06
1	T-Cutout Backface	4	1.51E-06	1.51E-06
3	Off Center Hole Rectangles	5	4.81E-07	1.44E-06
1	Connecting Pin	6	2.01E-07	2.01E-07
4	Pivot Hole Rectangles	7	6.39E-07	2.56E-06
2	One Hole Pin Support	8	1.79E-06	3.59E-06

2	Two Hole Pin Support	9	1.78E-06	3.55E-06
1	Pivot Reinforcement Middle	10	1.10E-06	1.10E-06
3	Eight Hole Adjustment Arm	11	5.03E-06	1.51E-05
2	Two Hole Adjustment Arm	12	5.13E-06	1.03E-05
4	Triangle Connector Joint	13	1.13E-06	4.53E-06
1	Diffuser Holder	14	5.34E-06	5.34E-06
1	Diffuser	15	8.52E-06	8.52E-06
			Total:	**6.21E-05**

4.0 Project Analysis

4.1 Material Analysis

Table 4 Benefits and Capabilities of materials

Material(s)	Capabilities and benefits
Silicone, Alumilite (Casted)	• Recyclable which contribute to sustainable design • Safe to work with materials as they can be deburred in various ways
Stainless Steel (CNC)	• Clean, reliable and extremely strong for its use in a USB Lamp
Rapid Prototyping (3D Printed)	• Result can be customizable in color and material and joints can be made with no effort • Can be easily modified if design modifications need to be made with simple power tools such as a dremel or a drill press.

4.2 Casting

Casting is one of the simplest processes and is fairly inexpensive. In this project a mold was made with the aid of cutouts which were made from a *fixed* template. A paper cutter was used to cut straight lines for the patters (Figure 16). These were then glued to a 1/8 in thick marker board and a band saw as illustrated in (Figure 17) was used to make these cutouts which were then drilled using a drill press. The speed of the drill press was 800 rpm and the hole was drilled with a 2.6mm drill. The pins needed to connect the arms and triangle pieces were in fact bolts with a size of 4/40 in or 2.54mm.

Figure 17 Cutting pieces using a band saw

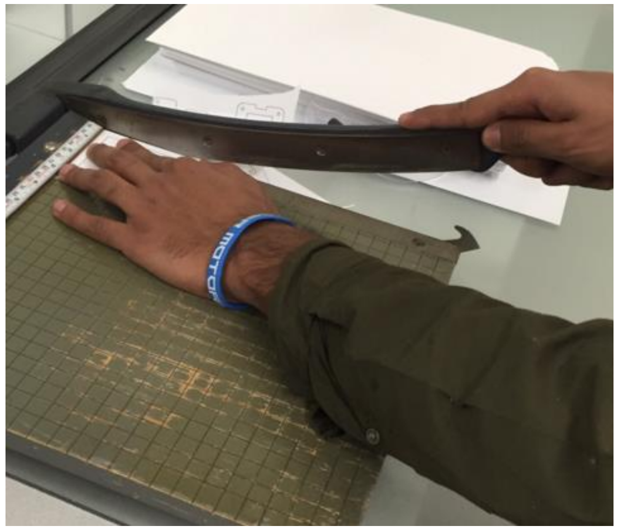


Figure 16 Cutting using a straight edge cutter

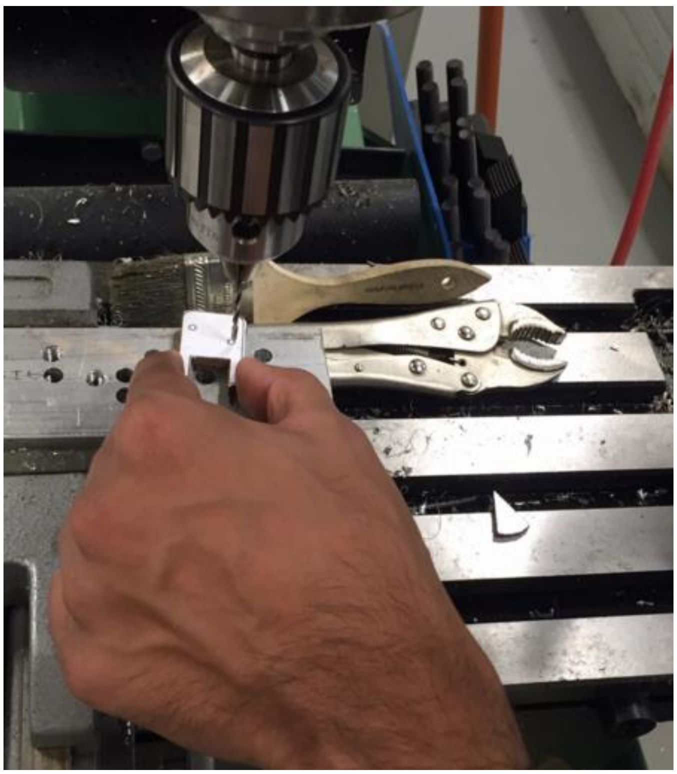


Figure 18 Aligning and clamping up work piece before drilling

After all of the parts were cutout and the holes were drilled they were laid out on a cardboard where they were fixated using a hot glue gun. WD40, an oil which allows for easy retrieval of the silicone mold was sprayed before pouring it in the housing. The following figures (Figures 19, 20 and 21) demonstrate the process. Note, the fixation of the pieces was done such in a way that the mixture required should be minimized. According to our volume calculations, we needed 600g of the mixed material. Hence 100g of material A was mixed with 500g of material B as instructed.

Note: some parts may appear to be unfinished or uncut as there are remains of the template. The reason for this is that the group did not have the required tools and the band saw blade only went to certain depths. This could have been avoided if parts were designed with using the band saw in consideration. However, after these parts were cast a dermal with a ¼ in sanding bit was used to clean the excess material.

Figure 19 Fixated parts and enclosure ready for silicone mixture to be poured

Figure 21 Silicone mixture being poured into enclosure

As illustrated in the figure on the left, the person on the left is controlling the flow of the silicone mixture and the person on the right is using a straight edge object (i.e ruler or Popsicle stick) to evenly distribute the mixture.

After the mixture was poured, the group noticed bubbles forming which would cause inefficiency in the mold and as a result the group started to remove them by popping them with a toothpick. This can be seen on the figure on the right.

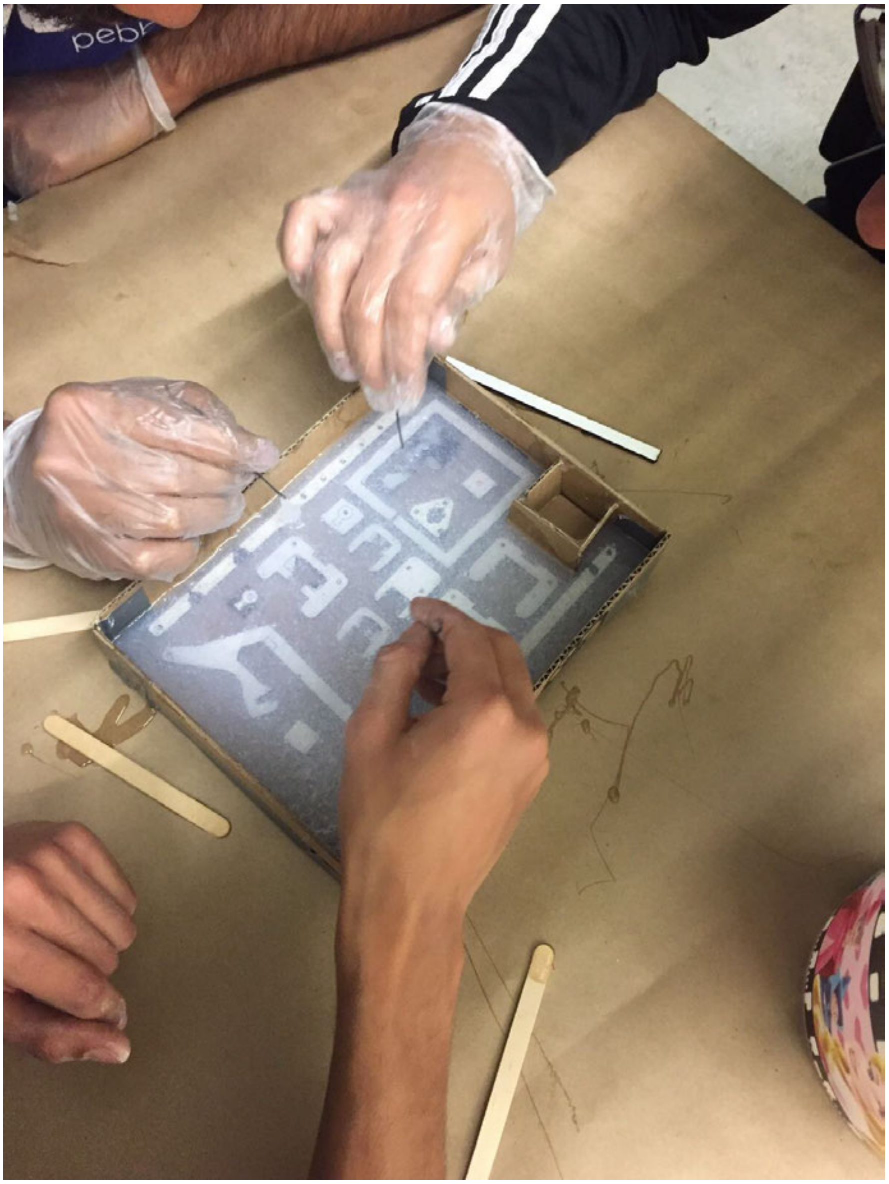


Figure 20 Illustrates the removal of bubbles after a silicone mixture was poured

4.3 Assembly and Finishing

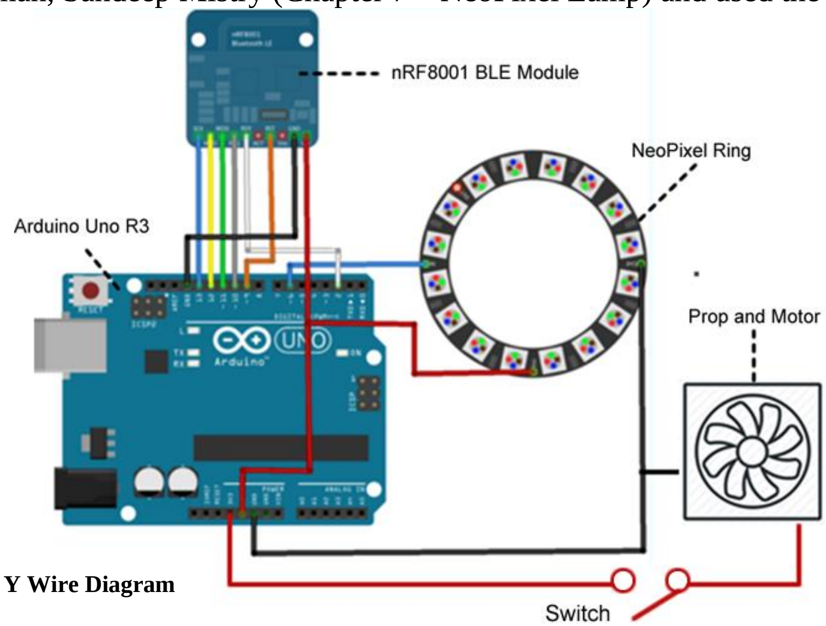
4.6 Electronic Components

Although Manufacturing and Process Design is equally important, having electronic features and adjustments are on the same scale. In today's digital age, majority of the control systems, gauges, dials are becoming electronic. There are several reasons for this, one could be the fact that it eliminates the cost of material and manufacturing and the other could be its easy implementation. People prefer to have controls for their devices, cars, airplanes etc. electronically as not only does it require less effort but can be easily customizable.

Hence, to illustrate this importance the group decided to incorporate an Arduino to control lights from a cell phone device and power a motor (fan) for one of the designs (Model Y). The following is a list of materials and parts that were used:

- AedaFruit nRF8001 BLE Module
- AedaFruit NeoPixel (12) Ring
- Arudino Uno R3
- 5V Motor
- 1” tri prop (fan)
- Jumper wire, shrink wire, single bright LED, switch, zip ties
- Stripped USB cable

In order to link all of these together the team used an example from a textbook “Make: Bluetooth, B luetooth LE Projects with Aruino, Rasberry Pi, and Smartphones” – Alasdair Allan, Don Coleman, Sandeep Mistry (Chapter 7 – NeoPixel Lamp) and used the following wire diagram:



Note: the NeoPixel Ring illustrated here has 16 RGB LEDs and our design has 12. The Red and Black wires represent positive and negative power supply. Other colors can be generalized as the necessary communication link between the Arduino and the Bluetooth module.

Figure 22 Model Y Wire Diagram

Figure 23 represents the wire diagram for the other design (Model X). A microUSB Cable was stripped and only the power supply (red), positive, and return (yellow), negative, were kept. The remaining two wires were discarded as they served the purpose of communicating with the computer and whatever end it was connected to. The single bright LED light had a built in resistor (100Ω) to control the power input received from a typical USB.

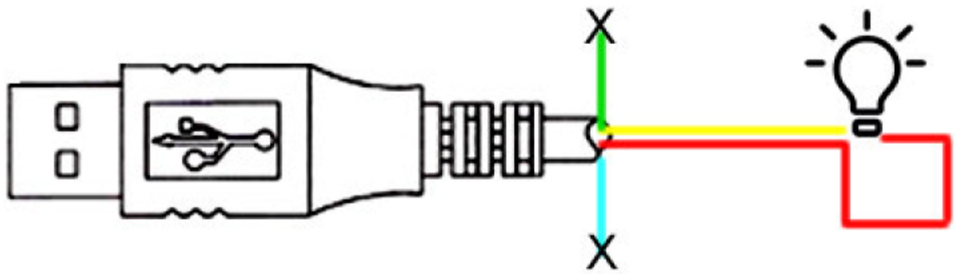


Figure 23 Model X Wire Diagram

Electrical Component Assembly

When it came to put all the electrical components together several measures were taken to insure that the soldering connections were firm. The Rapid Prototyping base was designed and

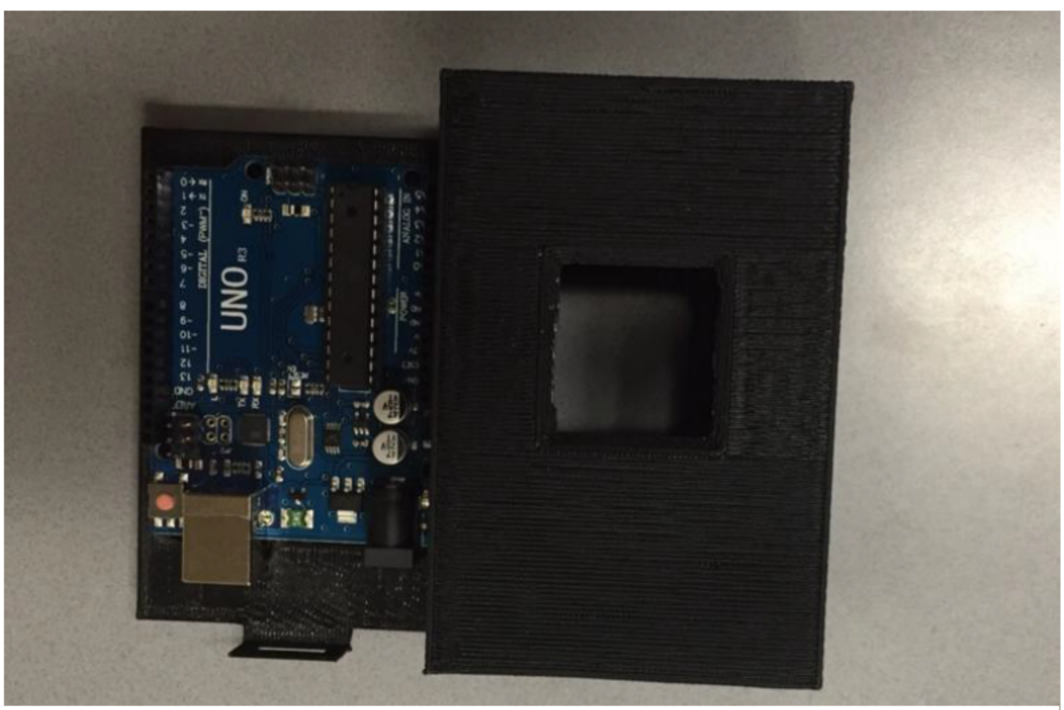


Figure 24 Rapid Prototyping Base. Bottom (left), Top (right)

constructed such that all of the wiring would fit accordingly with room for repairs. There were two sections to the base, the bottom (Figure 24) where the Arduino was settled and the top (Figure 24), which encompassed everything and had in insert for the lamp as illustrated in the figure below:

The circuit was wired onto a breadboard first to ensure that everything was working properly as illustrated in Figure # below. The motor was not part of this test as it was an independent system which was controlled from a switch and was grounded with the same wire from the NeoPixel Ring.

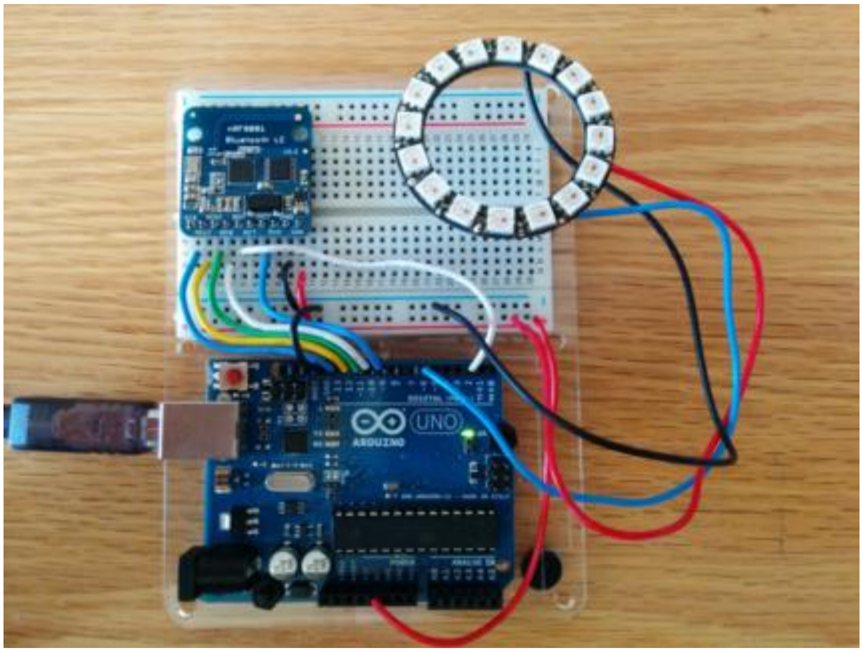


Figure 25 Model Y Breadboard Testing

After the test, the group realized that using a 16 NeoPixel ring was going to be too big in order to fit in the diffuser and hence went and purchased a ring that only had twelve RGB LEDs on it. This was all wired together using the same diagram and needed the same 5V power as its predecessor. All the connections were soldered together and the group made sure to use electrical tape on all of the connections as they did not any interference between them when they were encompassed in the Rapid Prototype housing. Shrink wire, which is made out of a plastic material that shrinks when it is heated up, was used for cable management and was specifically in black to match the color scheme of the design. This was then zip tied to the casted arms and the same technique was used for the Model X.

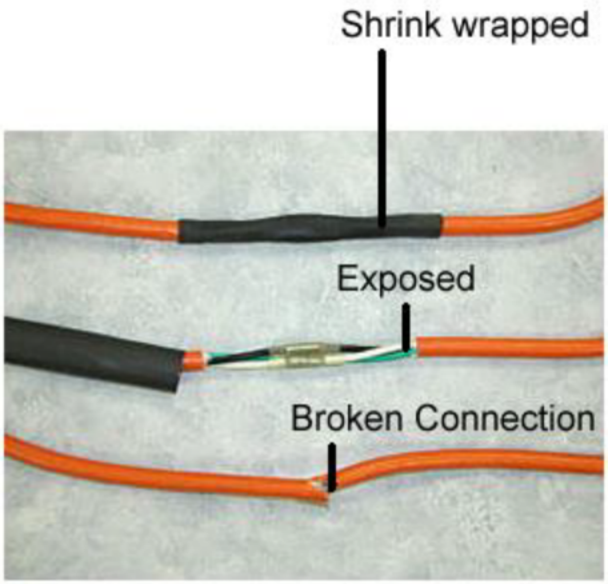


Figure 26 Importance of Cable Management

The following figure illustrates the importance of using shrink wire. When a joint of wire is exposed, it can contact other solder points and cause the circuit to not work properly.

4.7 Result

Model X:

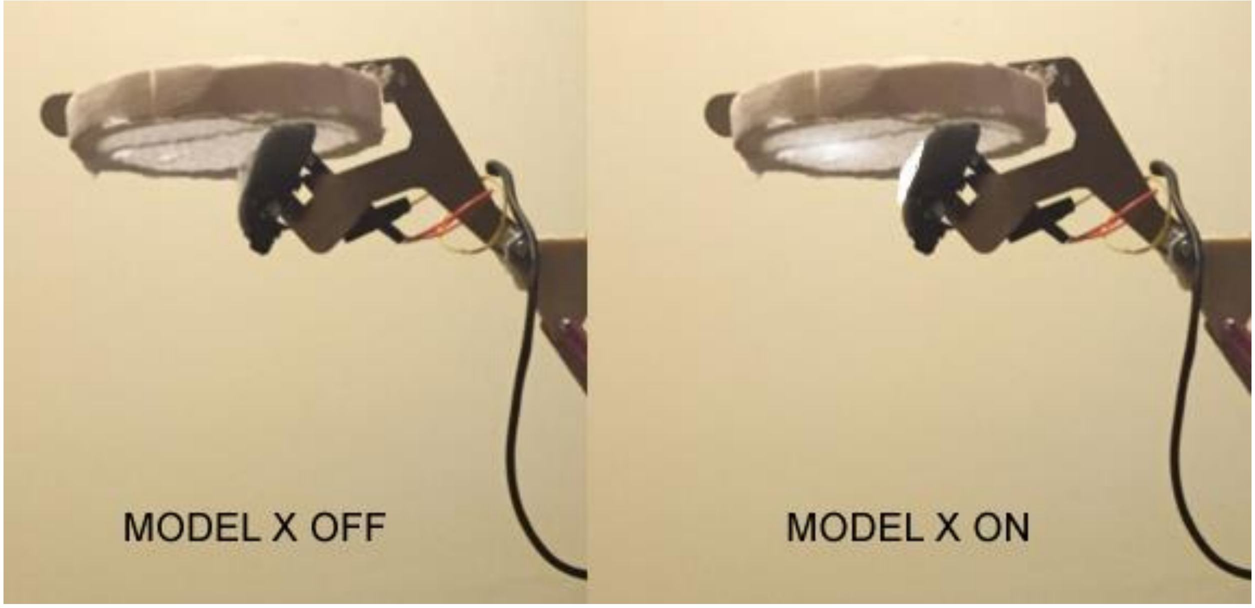


Figure 27 Demonstration of Model X

Model Y:

Figure 28 Demonstration of Model Y

Final Design Layout (Model Y):

5.0 Conclusion

The main goal of this project was to manufacture a USB lamp using different materials and manufacturing processes. Group 1 was combined of four bright engineers and was able to invent two professional models out of basic raw materials and demonstrate alongside manufacturing, the importance of implementing unique electronic features. By using the courses knowledge and the help of experienced instructors, students were able to accomplish the goal in a limited time and under a lot of pressure.

Group 1 had some rough time at first in communicating and the key to solve it was project management and leadership. Problems and barriers will appear in every project, but not every group can step over it. All four team member's stepped up and tackled the problems to overcome all barriers in a professional way. During the final stage, Group 1 reached to a great success and understanding which lead to two perfect products.

Team Picture:

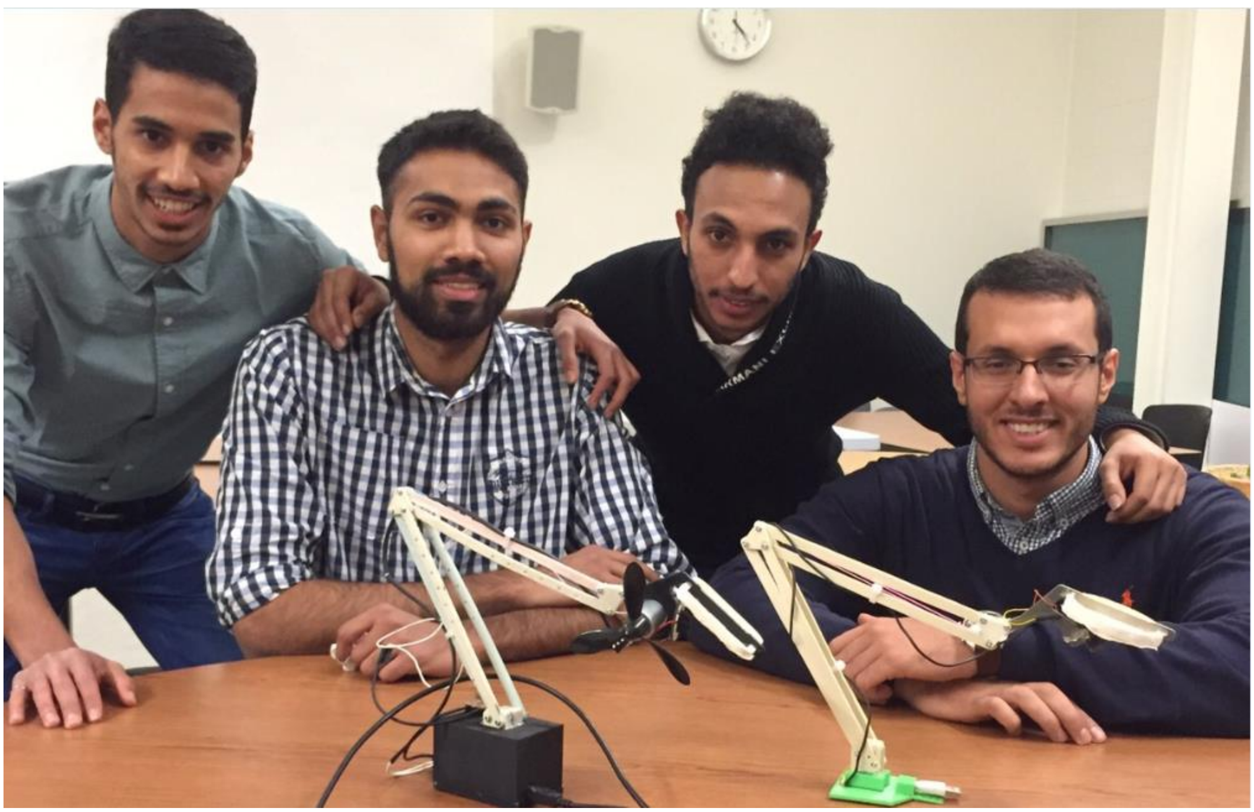


Figure 29 Team Picture

6.0 References

Alasdair Allan, D. C. (2014). *Make: Bluetooth, Bluetooth LE Projects with Arduino, Rasberry Pi, and Smartphones.* e-Book.

Casting, M. (2015, 11 22). *Metal Casting Basics*. Retrieved from thelibraryofmanufacturing: http://thelibraryofmanufacturing.com/metalcasting_basics.html

CATIA. (2015, 11 22). Retrieved from https://en.wikipedia.org/wiki/CATIA

Furtus 400MC. (2015, 11 22). Retrieved from Proto3000: http://proto3000.com/fortus-400mc.php

http://www.slideshare.net/nirjhar_jgec/product-design-concept. (2015, 11 22). *Product Design Concept*. Retrieved from Slideshare: http://www.slideshare.net/nirjhar_jgec/product-design-concept

Laser Cutting. (2015, 11 22). Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Laser_cutting

7.0 Individual Contribution(s)

Part Describtion	Part #	Mfg Process		Assembly Process		Who	How	When
		Process	Material	Process & Steps	Material			
Arms	1	Cutting, Casting, Drilling	Cardboard	Tight Fit		Samer,Ajwad Gouda,Alamoudi	Cei Resources	2015/11/25
Traingles	2	Cutting, Casting, Drilling	Sanding paper	Tight Fit				
U-shaped base	4	Cutting, Casting, Drilling	Alumilite	Tight Fit				
USB port Base	5	Cutting, Casting, Drilling		Tight Fit				
Connecting Pin	6	Cutting, Casting, Drilling		Tight Fit				
Diffuser	7	Cutting, Casting, Drilling		Tight Fit				
Diffuser Holer	8	Cutting, Casting, Drilling		Tight Fit				
Rotational Base	9	Rapid Prototype	Filament	Tight Fit		Samer, Gouda, Ajwad	Outside Connections	2015/12/1
Arduino Base	10	Rapid Prototyping	Filament	Tight Fit				
Fan designed diffuse holder	11	Rapid Prototyping	Filament	Tight Fit				
Second Diffuser Holder	12	CNC Machining	Stainless Steel	Tight Fit		Samer,Gouda	Cei Resources	2015/12/3

In addition to the table above, the following report contributions were made:

Name	Report Part(s)
Ajwad Ishaque	
Samer AlShaibani	
Mohammed Gouda	
Mohamed AlAmoudi	