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Development and production of a new solar table lamp

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Abstract

The modern world faces many problems including the inflation and the pollution. As the earth is becoming increasingly polluted it has become necessary to switch to clean and more efficient ways to produce new goods.

The answer to the above mentioned problem is the Technology. The technology is advancing at a very fast rate, and the results of these technological advances yield faster and better output at a reduced cost. Through these advances and through discovering of the new ways to do product development we can reduce the level of pollution and the costs associated with the human activities.

The aim of this project was to study and propose new design for a table lamp, to make it affordable, more energy efficient and eco-friendly. During the project many different lighting products were analyzed in order to add new characteristics to the lamp. After discussing several possibilities, with the help of 3D printing and solar technology, we were able to create the prototype of the desired lamp.

Acknowledgments

First of all, a special thank you to Jorge Lino for the permanent support, patience, advice, insightful criticism and guidance along the realization of this work.

I would also like to thank all the people at the company “Castro Lighting”

Giorgi Kvaratskhelia

“Design is elegance of intelligence”

Philippe Starck

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Chapter 1

Introduction

The problems of the modern world include: overpopulation, inflation and pollution. With the increase of the population the usage of the fossil fuels is also increasing, which increases the pollution and the price of the fossil fuels.

The world is dependent on the fossil fuels and is causing the ecological destruction of the planet to get it. The burning of the fossil fuels releases the CO_2 in the atmosphere which causes the global warming [1]. In order to deal with this problem we need to find the alternative energy source. The most promising of the alternative energy sources is the solar energy. The solar energy is a renewable energy source and harnessing it will not pollute the environment. There are four ways of harnessing the solar energy: passive solar heating systems, active heating solar systems, solar thermal power plants, and solar cells. Solar cells turn the solar energy into electricity.

The process of harnessing the solar energy is becoming increasingly popular in the world: the government of Morocco is building the thermal solar power plant in Saharan desert and they are planning to completely switch to solar energy by the end of 2020 [2]. The countries of the Europe and Americas are also involved in the processes of harnessing the solar energy.

With the previously mentioned increase of the awareness in the solar energy sources, the small solar panels for the households are also becoming popular. The household use the small solar panels to power the lamps, phones and the other small appliances.

The technology required for harnessing the solar energy is affordable and buying it will save the households a lot of money. More and more people are pursuing careers that are associated with harnessing the solar energy and more investments are made in this field. It is becoming evident that solar energy sources are very promising and reliable and will very soon replace the fossil fuel sources.

The technology that is very versatile and can be combined with a lot of technologies is 3D printing. Even though the 3D printing was invented in 80s [3], by that time it was way too massive and expensive. However with all the advancements in technology the technology of 3D printing became more effective, affordable and popular. Some experts are thinking that it can cause the third industrial revolution.

The products manufactured with 3D printing are eco-friendly and they can be easily recycled. 3D printers can manufacture products of any shape. Compared to the traditional manufacturing methods of the products, the 3D technology is faster and cheaper. 3D printing can enable us to manufacture the products locally and in household conditions. 3D printing can help the customers to save time, energy, money and to affect the ecology positively [4].

Another factor that affects the environment is the overproduction tendencies in the world. The current economies of the world are always trying to increase its gross domestic product and the output of the production. And because of these competitive tendencies there might be more products manufactured than needed. In some cases most of the manufactured products are useless. The cynical design has been established where the manufacturers are trying to manufacture as much useless products as possible and sell it for the highest price possible [5].

The modern people use a lot of products, energy and the resources. They buy some products not out of the need but because that product might be fashionable, relevant or popular. This attitude jeopardizes the customer and the environment and that is why today we need more ethical and honest design [6]. We should manufacture the product that can last longer and will require less effort or energy. We should change the disastrous ways of consumption and buy only necessary products. Meaning that the products that are already bought should be used more efficiently and no resources should be allocated if the making of a new product is not beneficial. This way we can positively affect the environment. However, the people are not judging the product only by what it can do, but also by its design and esthetics. The customer develops an emotional attachment towards the product. That is why the design of the product must be practical and elegant in order for the customer to keep it for a long time [7].

To achieve the creation of the above mentioned ethical, energy efficient and eco friendly product we decided to make the 3D printed solar lamp. This lamp would work by charging on the direct sunlight through its solar cells and would be self-sufficient. We designed the lamp to be elegant and timeless with the organic shape.

1.1 Document outline

This dissertation is divided in four main chapters. We will summaries the contents of each chapter.

Chapter 1: Introduction

In this chapter we want to provide the reader a contextualization of the project, the goals to achieve at the end of this dissertation and also explain the structure of the work which is expected to be developed.

Chapter 2: State of the Art

Chapter two gathers all the information upon which we based our work. Information related to solar energy consumption around world and also 3D printing technology impacts on environment. Data related to solar panel industry and 3D printing production.

Chapter 3: Project development

This chapter describes all the stages that we went through during the development of our project. It includes the concepts and prototypes. We also described the methods used to develop each step of the process until we got a prototype and a proposal to a product.

Chapter 4: Conclusions and future work

Chapter four aims to summarize the work done until the submission of this dissertation.

References

The citation style used in this dissertation is the Vancouver.

Chapter 2

State of the art

2.1 Solar energy and 3D Printing

The present chapter aims to provide the reader with an approach to the facts, statistics and aspects related to solar energy and 3D printing technologies.
Solar energy and 3D printing are in developing stages and because the information about this kind of technology is recent, we are forced to use ordinary websites to get information and statistics.

Solar energy industry seems to be very promising the number of jobs in the solar industry in the U.S. rising every year .There are more people working in solar energy fields now than at oil rigs. That is why according to a nonprofit organization in Washington D.C. called the Solar Foundation the solar industry added 35,000 jobs in 2015 which is 20% increase compared to the previous year (**figure 2.1)** [8].

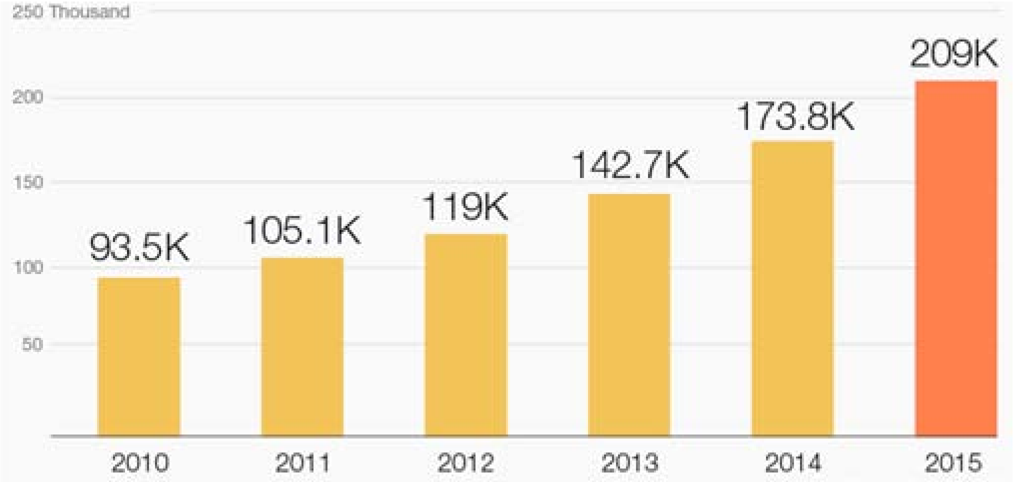

Figure 2.1: Total employment in solar energy industry 2010-2015 in USA [8].

The productivity levels of the solar energy companies are staggering as through the first half of the year alone, the solar industry has supplied 40% of all new 2015 electric generating capacities - more than other possible energy technology. With about 5,000 MW of installed solar capacity projected over the second half of 2015, the U.S. solar industry is thought to reach nearly 8,000 MW for the year, and 28,000 MW in total. Other key takeaways are depicted in **figure 2.2** and **figure 2.3** [9].

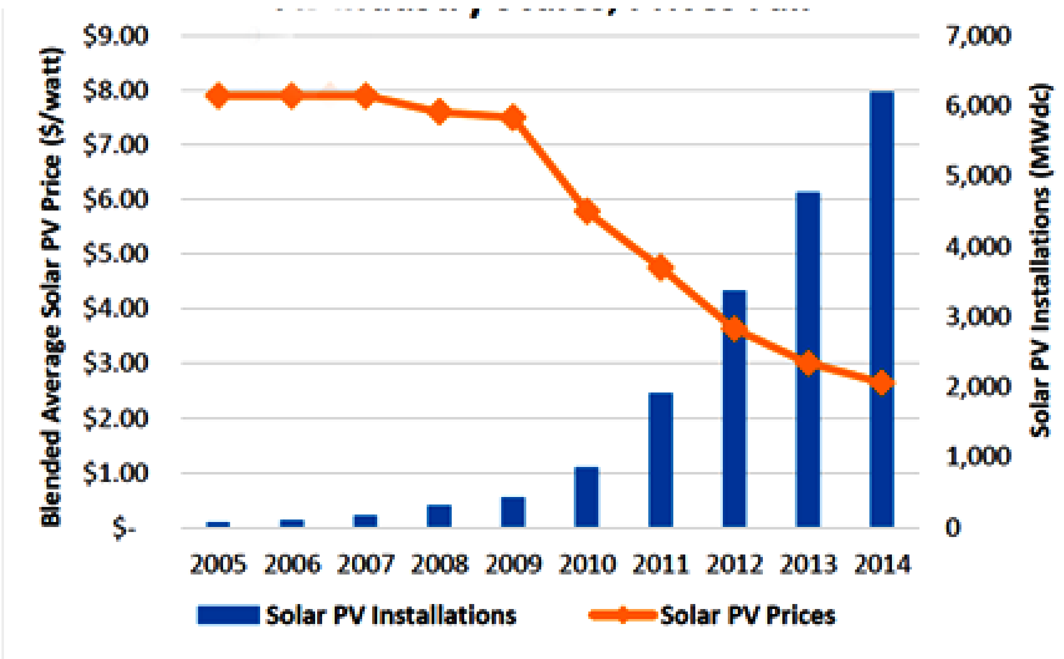

Figure 2.2: U.S. solar Installation statistic [9].

BP prepared the data for the installed solar photovoltaic capacity in several countries along with the amount of solar electricity spent. This makes it possible for the solar load factor to be computed. If we take the currently used capacity and multiply it by 24 hours and 365.25 days, this will give us a theoretical maximum electrical output with which the actual output can be compared. The results can be seen in **figure 2.3** and **table 2.1** [10]

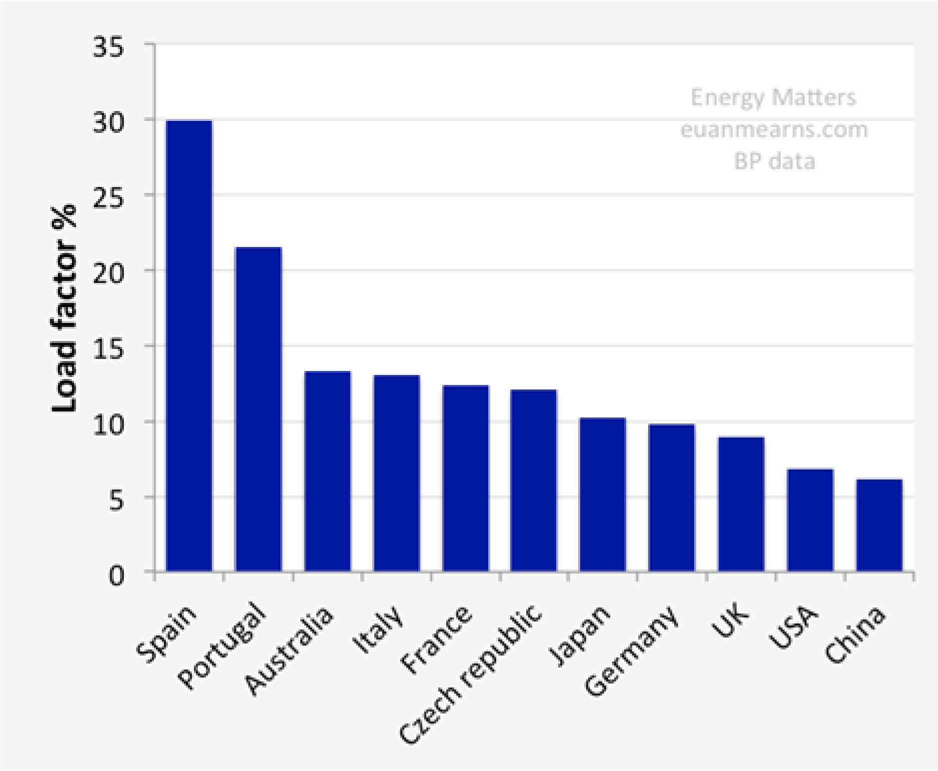

Figure 2.3: Solar PV load factors [10].

Table 2.1: Solar photovoltaic [10].

	GW installed	TWh consumed	maximum output	Load factor %
USA	7.3	4.4	64.1	6.86
Czech republic	2.1	2.2	18.2	12.11
Frane	3.7	4	32.4	12.36
Gemany	32.6	28	286.1	9.79
Italy	16.2	18.5	142.4	12.99
Portugal	0.2	0.4	1.9	21.52
Spain	4.5	11.9	39.8	29.92
UK	1.7	1.3	14.5	8.96
Australia	2.4	2.8	21.1	13.26
Chine	8.3	4.5	72.8	6.18
Japan	6.9	6.2	60.6	10.23

2.2 Environment and 3D Printing

Compared to the traditional methods 3D printing has reduced the manufacturing costs by thousand. At first 3D printing was used for the creation of the product prototypes that was later finished with the traditional manufacturing. But in time 3D has advanced enough to be able to manufacture the finished products faster and cheaper than the traditional methods do. Also the products manufactured by the 3D printing are a lot lighter and cheaper than the products manufactured by the traditional methods [11].

The 3D printing technology will force the manufacturers to change their manufacturing structure and business model. The manufacturing will become local and the current world manufacturing system will be decentralized. The big-scale manufacturing operations will turn into many local small-scale manufacturing operations[12]. This transformation will reduce the transporting costs and hence will reduce product prices while also reducing the pollution [3].

As the modern world is being digitalized more households and people are getting the access to the personal computer, which allows the transfer of the information to be done anywhere on the planet. This type of connection could hardly be imagined 10 or 20 years ago; however the internet caused the revolution that connected the whole world. The 3D technology has the potential to cause the same kind of revolution in 10 years. Because in the future the 3D technology will be in most offices and households and the people will be able to use it at homes or at the offices. The people will not buy the finished good from the shop but rather they will buy the model online that they will be able to print out at home or at the local manufacturer's shop [13], as shown in **figure 2.4** , **figure 2.5**, and **table 2.2** [14, 15].

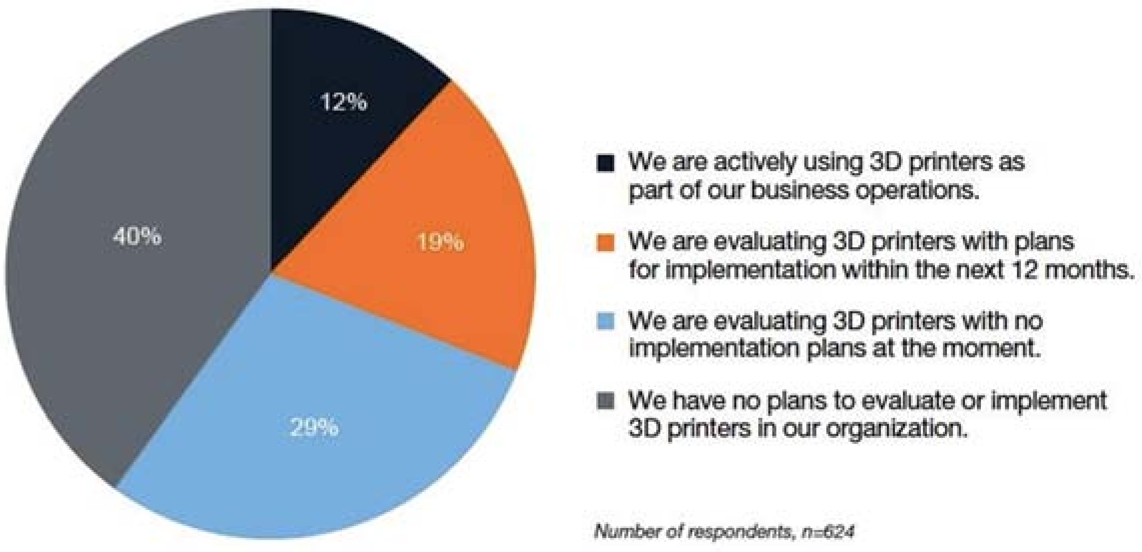

Figure 2.4: Current use or future plans for 3d printing [16].

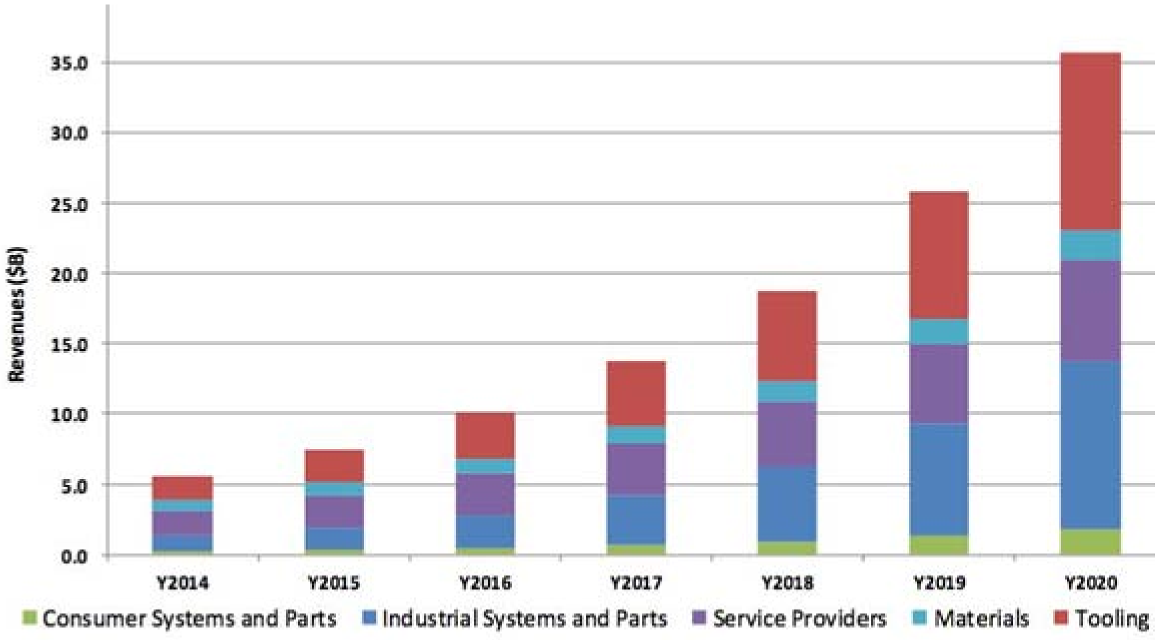

Figure 2.5: Revenue forecast for the 3d printing industry from 2014-2020 [15].

Table 2.2: 3D printing vs. machine tooling and plastics injection molding [15].

Part/Tool	Customer	3D printing tecnology	Alternative method
End of arm robot		FDM $600 24 hours	$10.000/4 weeks
Automated turntable		FDM $8,800 2 weeks	$50.000/8 weeks
Stell plates		FDM $20 2 hours	$200/2 weeks
Inejction mold		Poly jet $1.350 /day	$54.000/8 weeks 500kg metal

2.3 Components

Below we will present components for solar lamp.

Magnetic wireless charger

Exelium wireless charger, (**figure 2.6**), uses an electromagnetic field to transmit energy between two objects. This is usually done with a charging station. Energy is sent through an inductive coupling to an electrical accessory, which can then use that energy to charge batteries or run the device. The wireless charger can charge almost every type of smart phones.

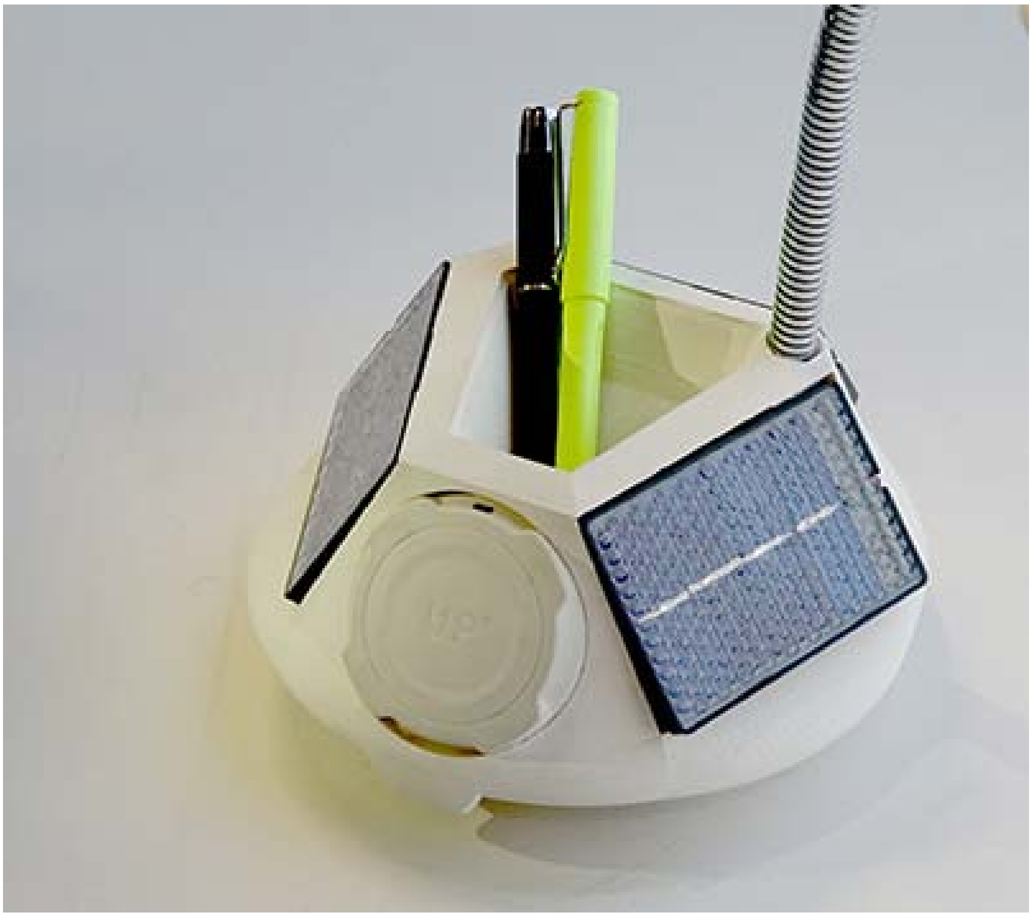

Figure 2.6: Exelium wireless charger.

Solar panel

Solar Photovoltaic panels create the solar array of a photovoltaic system that generates and supplies solar electricity. Solar panel, (**figure 2.7**), can produce only a limited amount of power. This panel is 3 millimeters in width and 62 millimeters in diameter and it can generate 2 volts of electricity.

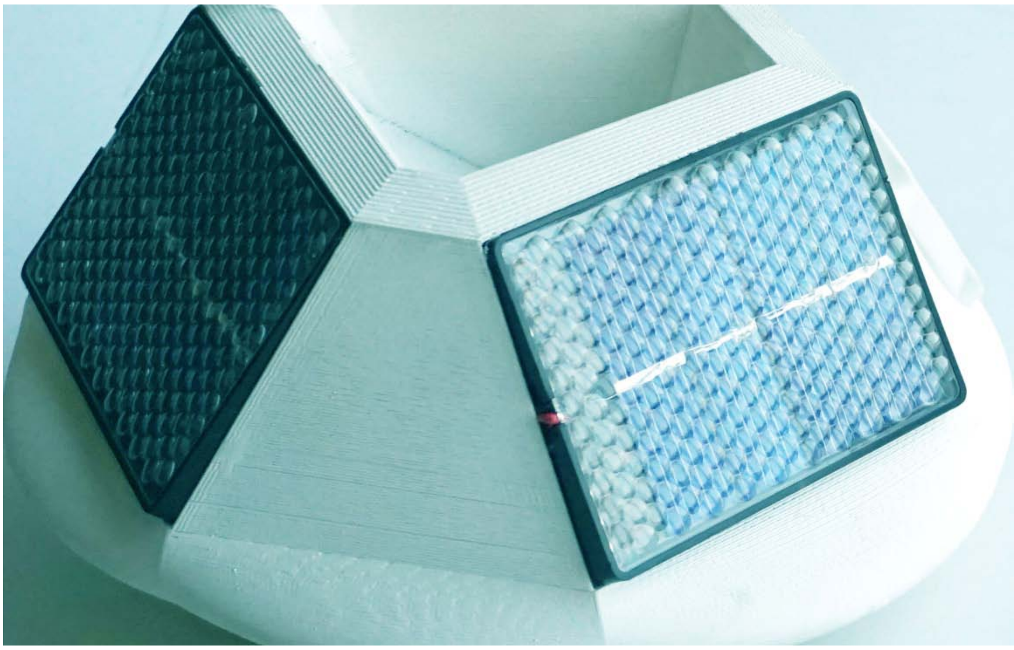

Figure 2.7: Small solar panel.

The electric system employed is a typical system available in the market that is composed by a common solar panel, with a rechargeable battery indicated in (**figure 2.8**).

Figure 2.8: Ni-Cd rechargeable batteries.

LED light

LED lights can last longer than ordinary (luminous or fluorescent) light bulbs which can ultimately lead to saving money.

LEDs do not contain harmful chemicals and are considered as more friendly to the environment. LEDs have significantly low carbon footprint (**figure 2.9**) [17].

Figure 2.9: LED lights.

Solar Power Bank

Solar power bank is a battery power storage unit that gets recharged with energy from the sunlight. These types of the banks are convenient during camping outings where there are no electricity sockets. If one decides to purchase a solar power bank, they must make sure that have connection to suitable sunlight to charge it, and that when they are not outside they have got a way to charge it from an outlet. Often it is displayed as more of an emergency choice and not as the predetermined main source of power.

Many users found that the most time saving way to get the full charge of the battery is to let the bank power up through sunlight while also being connected to a wall outlet at home. However the solar power banks are a great contribution for people who spend a lot of time outside of the reach with electricity while still requiring several electronic gadgets (**figure 2.10**).

Figure 2.10: Solar power bank [18].

Table 2.3: List of part quantities

Components	Quantity	Price (EUR)
Small solar panels	4	25
Ni-Cd rechargeable battery	3	6
LED lights with controller	3	15
Wireless magnetic charger	1	35
Metal support	1	5
3D printed parts	3	200
Sum	15	286

2.4 Introduction of the Company "Castro Lighting"

Design Company "Castro Lighting" hosted my internship. At first I did research of company's factory and how they manufacture lighting products. Mostly they manufacture lamps from brass. I pictured all the stages of manufacturing process.

Cutting brass tubes by Metal Cutting Saw

A cold saw is a round saw designed to cut metal which uses a toothed blade to transmit the heat generated by cutting to the chips created by the saw blade, allowing both the blade and material which is being cut to remain cool (**figure 2.11**) [19].

Figure 2.11: Cutting brass tubes by metal cutting saw at "Castro Lighting" factory.

Drilling

Drilling is a cutting process that uses a drill bit to cut a hole of round cross-section in tight materials. The drill bit is usually a spinning cutting tool. The bit is pushed against the work piece and rotated at rates thousands of rotations per minute (**figure 2.12 to figure 2.16**) [20].

Figure 2.12: Making hole in metal with drill at “Castro Lighting” factory.

Figure 2.13: Making hole in brass with drill at “Castro Lighting” factory.

Figure 2.14: Drilling brass plate to fix at “Castro Lighting” factory.

Figure 2.15: Drilling brass plate to fix at "Castro Lighting" factory**.**

Figure 2.16: Drilling brass plate to fix at "Castro Lighting" factory.

Oxy-fuel welding

In oxy-fuel welding, a welding torch is used to weld metals. Welding metal develops when two pieces are intense to a temperature that produces a shared pool of fused metal. The fused pool is generally equipped with additional metal called filler. Filler material depends upon the metals to be welded (**figure 2.17** , **figure 2.18**) [20].

Figure 2.17: Shaping decorative brass pieces by oxy-fuel welding at “Castro Lighting” factory

Figure 2.18: Shaping decorative brass pieces by oxy-fuel welding at “Castro Lighting” factory

Metal spinning

Metal spinning, also known as spin forming or spinning is process by which a disc of metal is rotated at high speed and formed into an axially symmetric part (**figure 2.19** , **figure 2.20**) [21].

Figure 2.19: Shaping brass plate by machine by metal spinning at "Castro Lighting" factory.

Figure 2.20: Shaping brass plate by machine by metal spinning at "Castro Lighting" factory.

Electrostatic coating

Electrostatic spray powder coating uses a mix of powder and air for operation. The powder-air mixture is supplied through a hose from a small fluidized bed in a powder feed hopper (**figure 2.21**) [22].

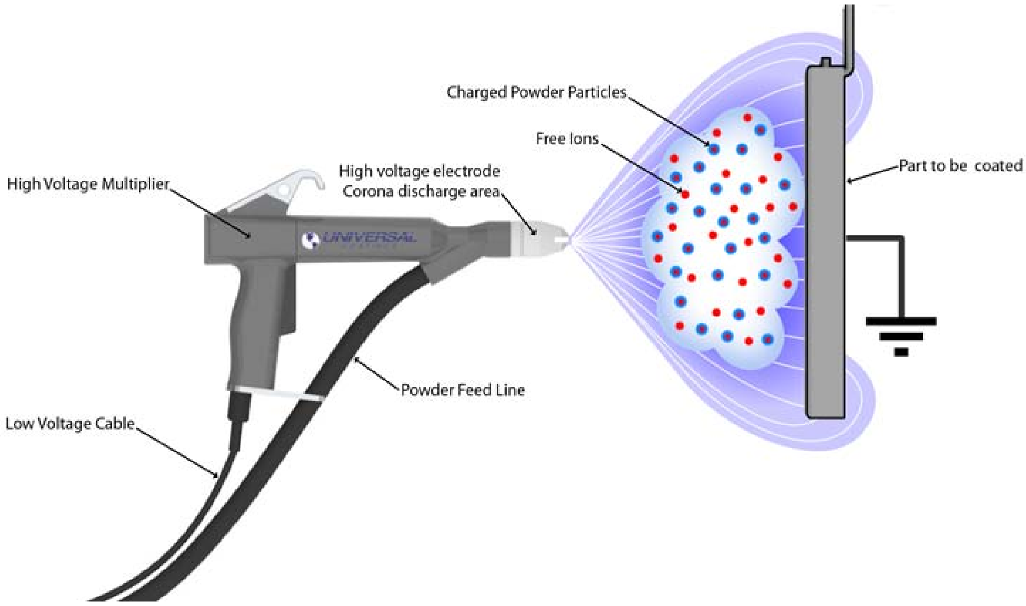

Figure 2.21: Electrostatic spray powder coating process [22].

Chrome plating

Chrome plating is a technique of electroplating a layer of chromium on a metal or item. The chromed layer can be fancy or for corrosion protection.

Chrome plating process phase: extract of heavy soiling, manual cleaning to extract all residual fragments of dirt and surface impurities (**figure 2.22**, **figure 2.23**) [23].

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Figure 2.22: Chrome plating brass parts at “Castro Lighting” factory

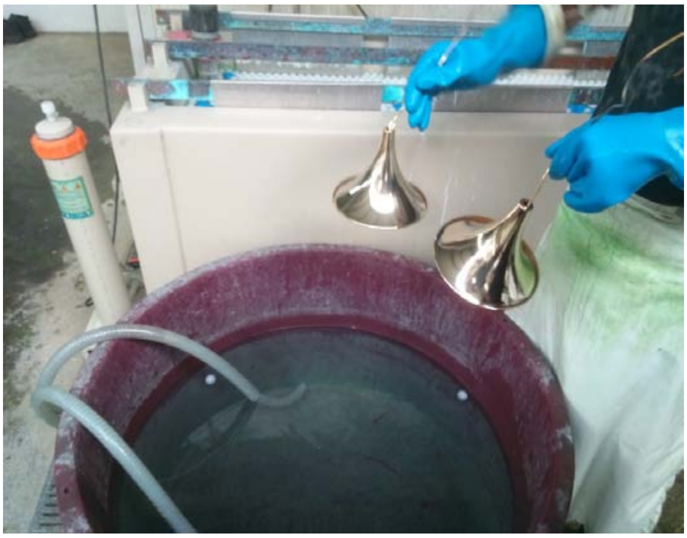


Figure 2.23: Chrome plating brass parts at “Castro Lighting” factory.

Brass Polishing

Metal Polishing is the procedure of extracting scratches from a surface, and generate the desired brightness of finish on surface. Polishing, like using sand paper, consists of procedures each of which is less abrasive than the previous ones (**figure 2.24**) [24].

Figure 2.24: Polishing brass basement by polishing machine at “Castro Lighting” factory.

2.5 Product analysis

We analyzed existing lighting market. We collected the information about the interesting lighting products.

D'E-light

D'E-light is a table lamp from Flos, which contains a dock for “I Phone” and “I Pad” and also has practical design and a light source. Designed by Philippe Starck, this efficient refined aluminum light contains a USB socket above the light diffuser. Flos merging of lighting and informational technology has led to the creation of an object that is entirely adapted to the modern habits of today's always-connected culture (**figure 2.25**) [25].

Figure 2.25: Task Light by Philippe Starck [25]

Ipparco Table Lamp

Ipparco is a basic and practical table lamp for the working or the home environment. The most crucial thing in the design of this lamp is the accurate consideration of function and form in balanced measure. This lamp contains a powerful magnet which allows its ring shaped light source to stand anywhere on the framework and to set the circle of light in any direction, offering its user unlimited adaptability in the direction of the light (**figure 2.26**) [26].

Figure 2.26: Artemide Ipparco table lamp by Neil Poulton [26].

Meccano Lamp

Meccano is far more than only a lamp, the cheerful design boosts the level of interaction. The product contains unlimited possibilities for the user's imaginative mind to express itself in this devised game. From basic table lamp to the task light, the smart form can easily and naturally be adjusted to accommodate just about any need or aesthetic setting. In a way the customer turns into the designer as they can choose the fashion, design and structure of their product (**figure 2.27**) [27].

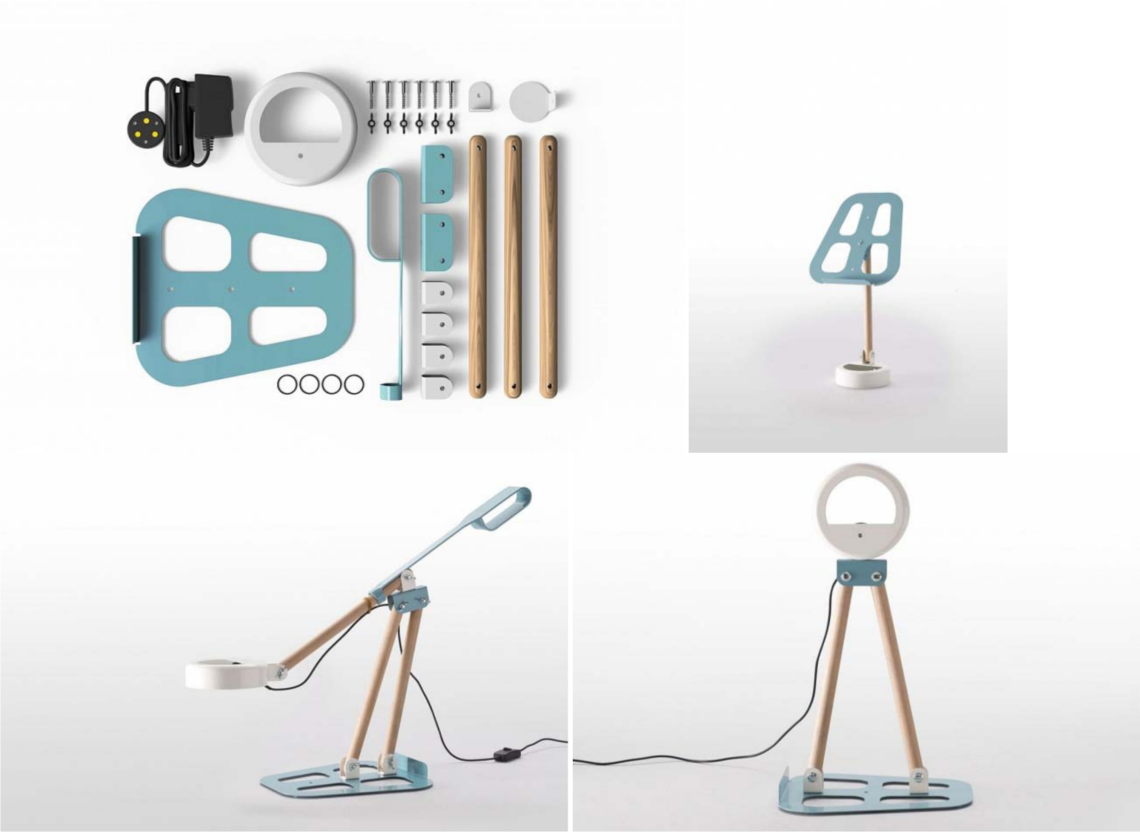


Figure 2.27: Meccano lamp [27]

2.6 Conclusion

This chapter contained information and statistics about solar and 3D printing technologies. The information in this chapter indicates that the solar and 3D printing technologies are very promising. The chapter also included the analysis of several interesting lighting products and its components. From such analysis we were able to make decisions which lead to creating the concept of our lamp.

Chapter 3

Project development

3.1 Product developing process

Product development started during the internship in the company that manufactured lighting products, called “Castro Lighting”. The company mainly specializes in manufacturing lighting products and furniture. The lighting products are usually made from metal. They wanted to come up with a design of a lighting product for their new collection. The new lighting product had to be made of metal and it had to have an organic shape. In order to study the current lighting product market and to identify the needs of the customers we started researching the market. The research process lasted for couple of months and during that process we came up with several possibilities to develop a design presented in (**figure 3.28 to figure 3.31**).

Figure 2.28: Sketches of the lamp.

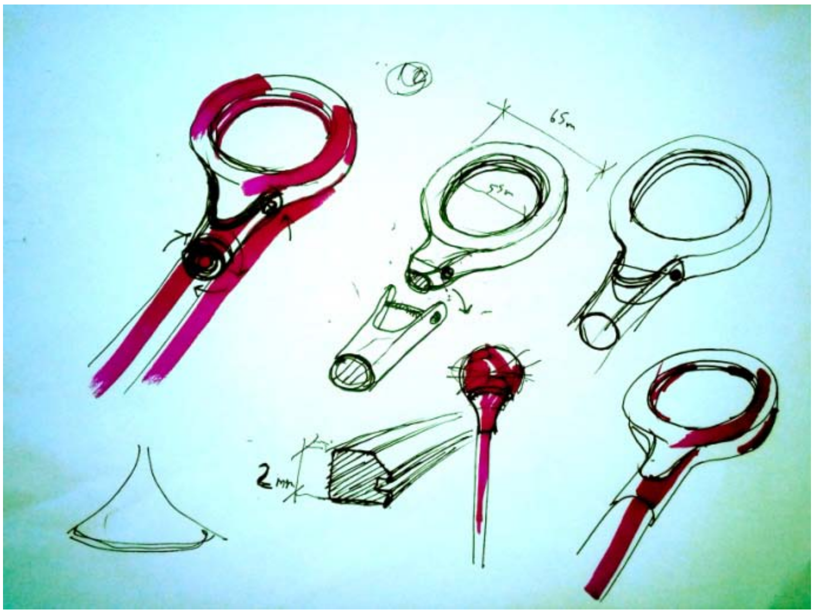


Figure 3.29: Sketches of the lamp.

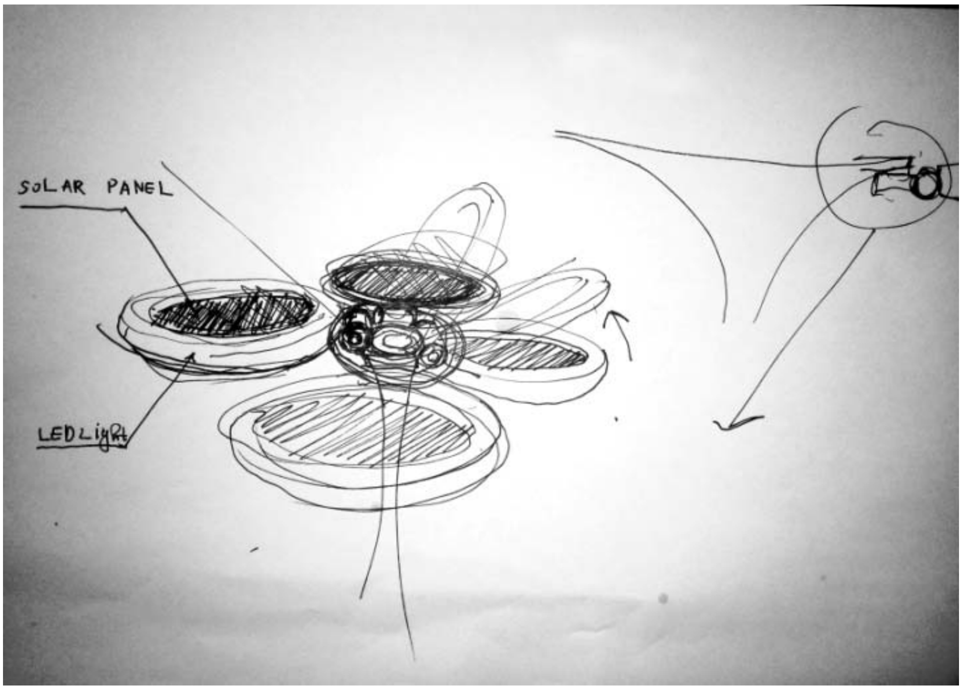


Figure 3.30: Sketches of the lamp.

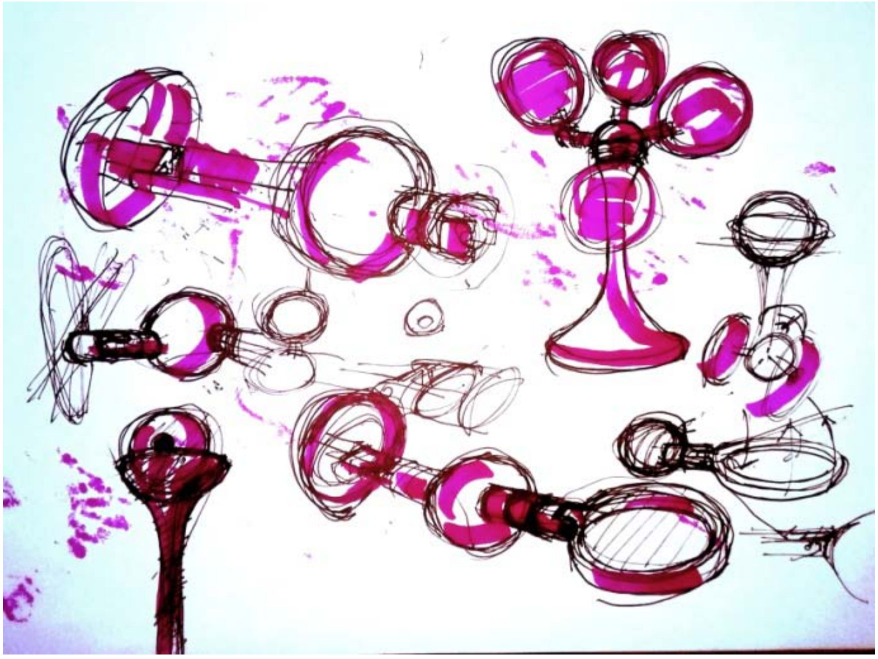


Figure 3.31: Sketches of the lamp.

However soon we narrowed down all the possibilities to a single idea of making a lighting product that would be able to charge with the solar power and it would have a dock for charging a phone. The reason we decided to go with this idea is that the demand for such products is increasing at a very fast rate.

After we made a decision about the type of the lighting product that could best satisfy the needs of the current customers we started researching the information about all the machinery and the parts that could help us build the particular lamp. We wanted the parts to be small and inexpensive so that the lamp could be as affordable as possible. After gathering the information about the possible parts of the lamp we started working on the design of the lamp presented in (**figure 3.32 to figure 3.36**)**.**

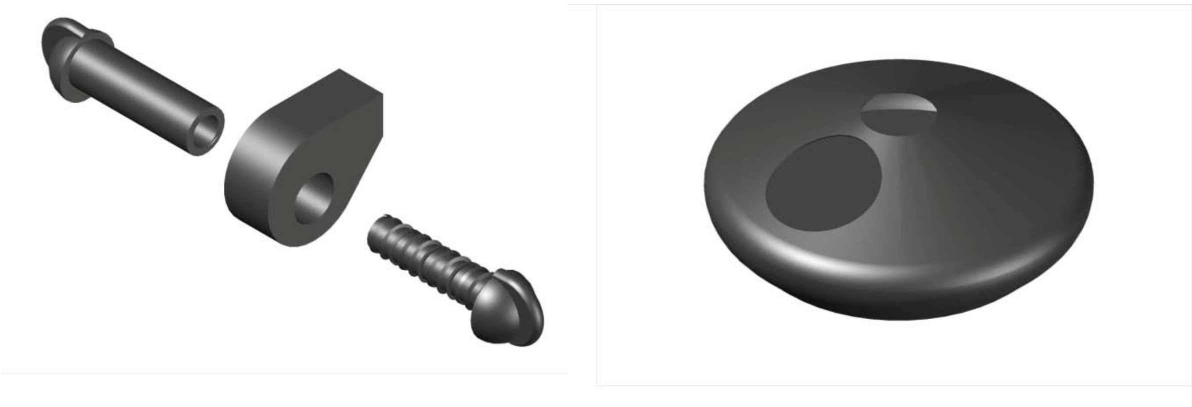


Figure 3.32: Sketches of the lamp.

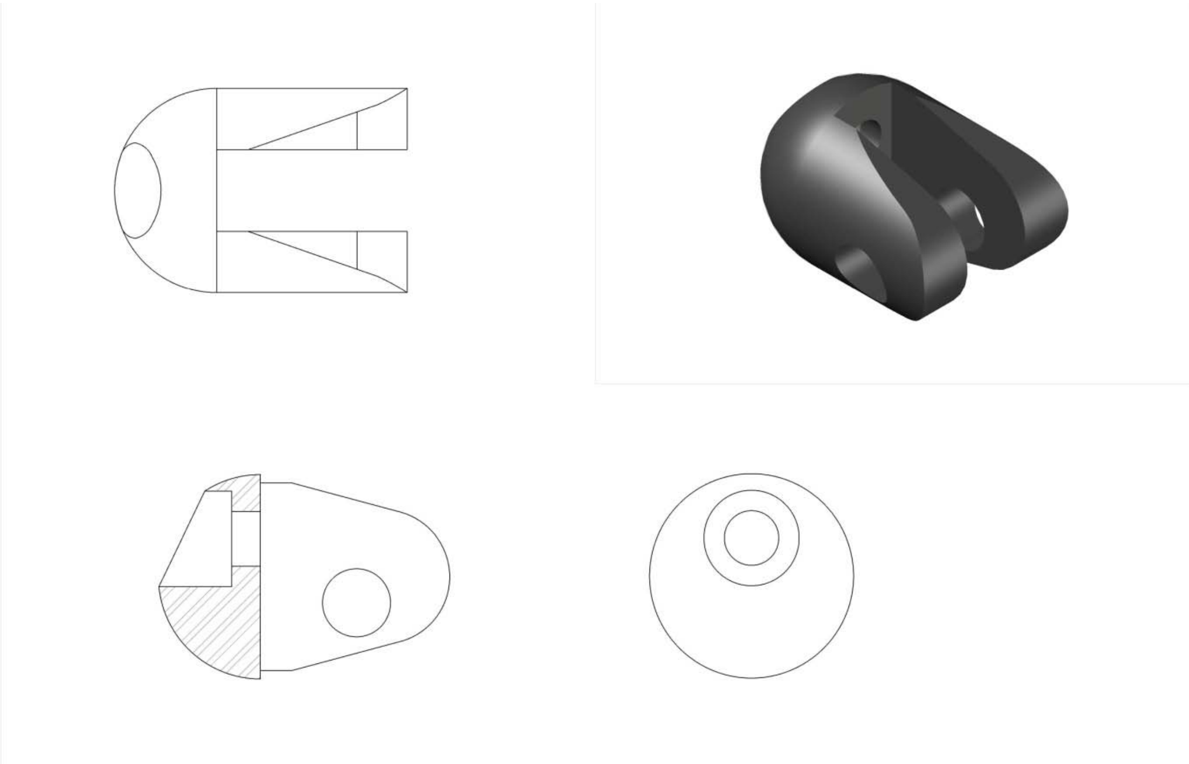


Figure 3.33: Parts drawing for brass solar lamp.

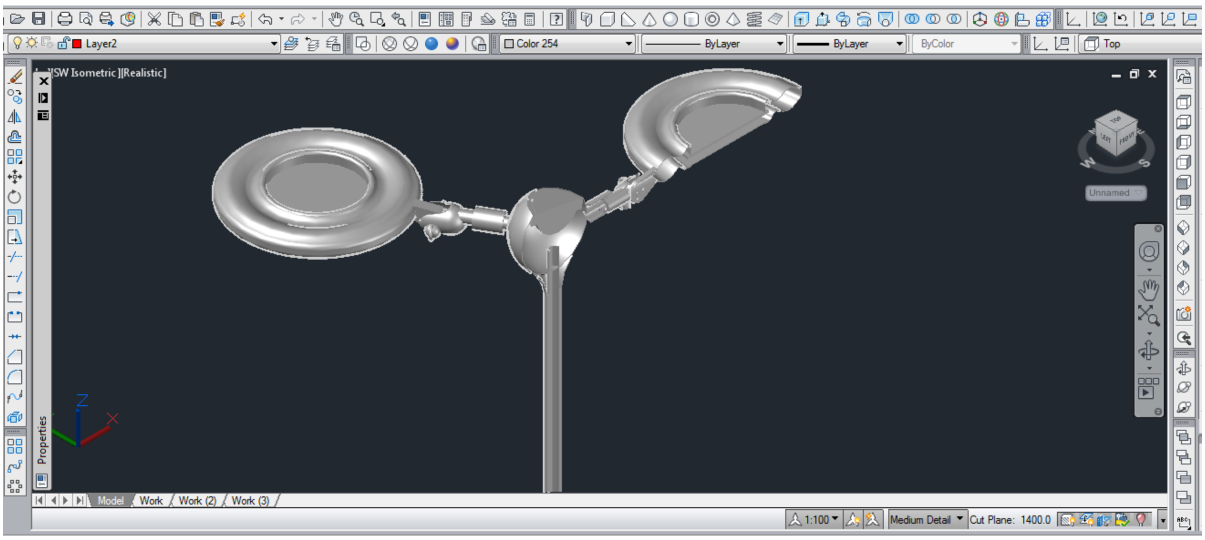


Figure 3.34: 3D model section of brass solar lamp.

Figure 3.35: First version brass chromed lamp for “Castro Lighting.”

Figure 3.36: First version brass chromed lamp for “Castro Lighting.”

Unfortunately, the company “Castro Lighting” was not interested in production of this lamp, since it was not a luxury product which the company was looking for at the time. In order to achieve the production of the lamp we had to search for solutions outside of the company.

The best solution that we could find to achieve our mission was the 3D printing. The reason the 3D printing was more beneficial is that with it we could manufacture any shape for less costs. The 3D printing gave us the versatility we needed to create different parts of lamp presented in **figure 3.37 to figure 3.44**.

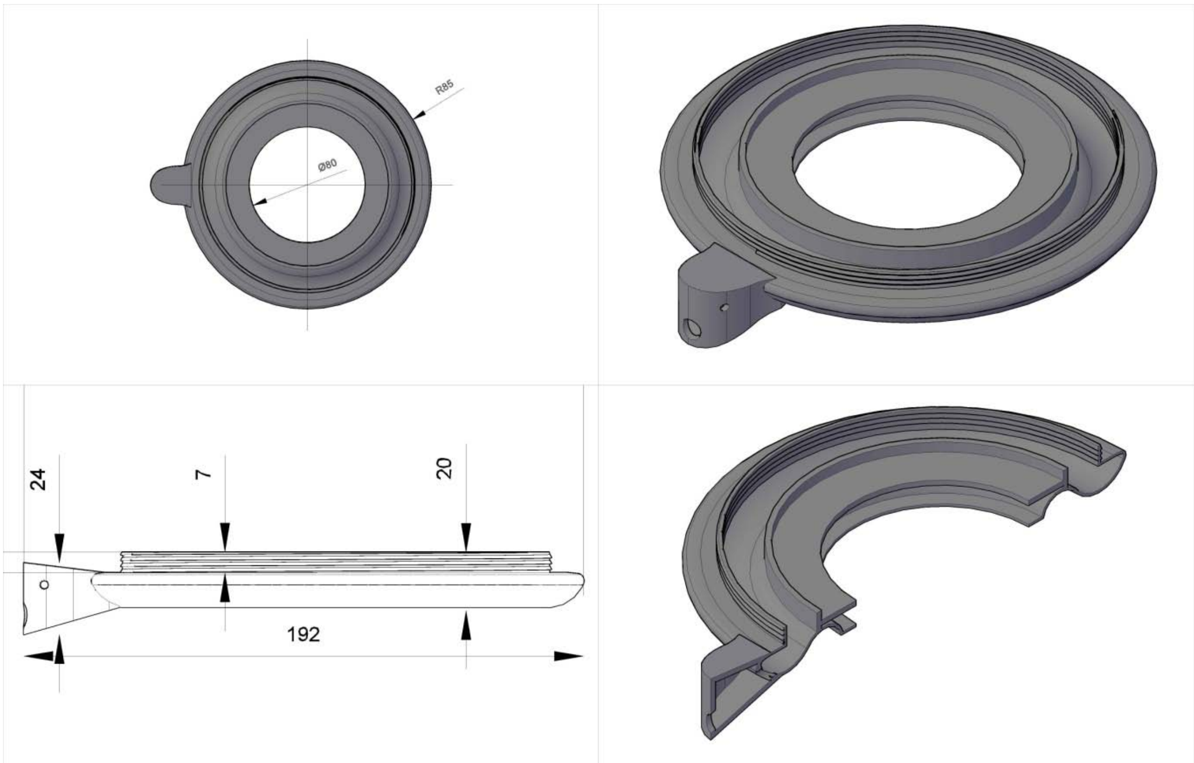


Figure 3.37: 3D model parts for lamp.

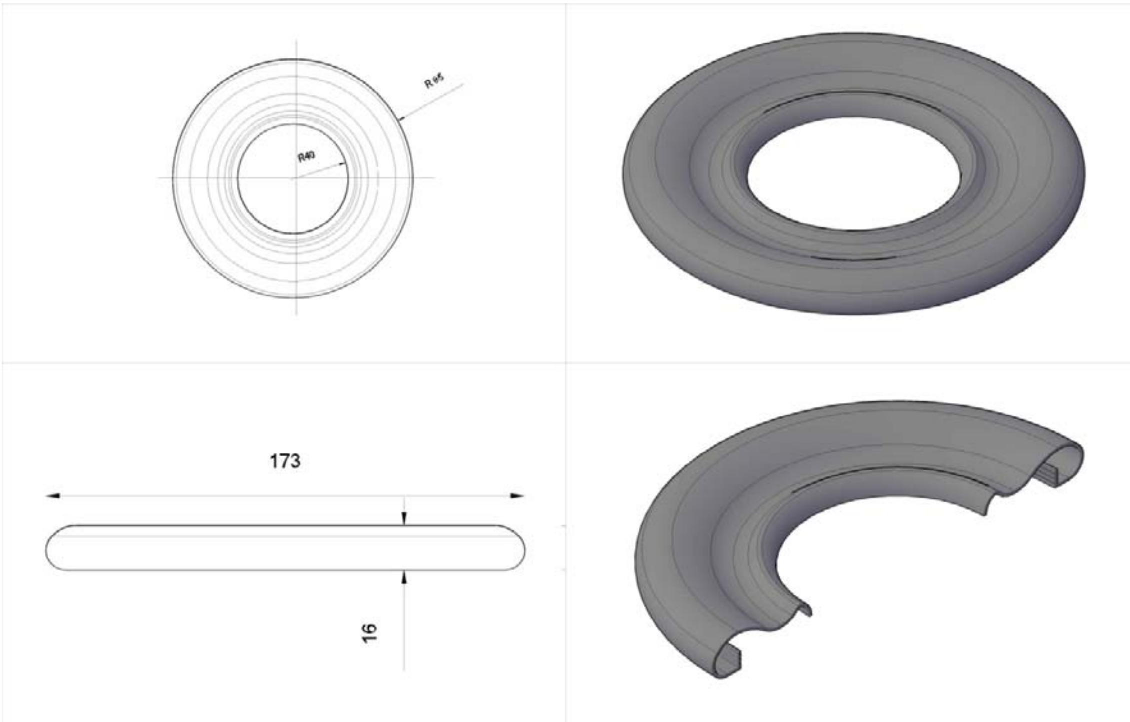


Figure 3.38: 3D model parts for lamp.

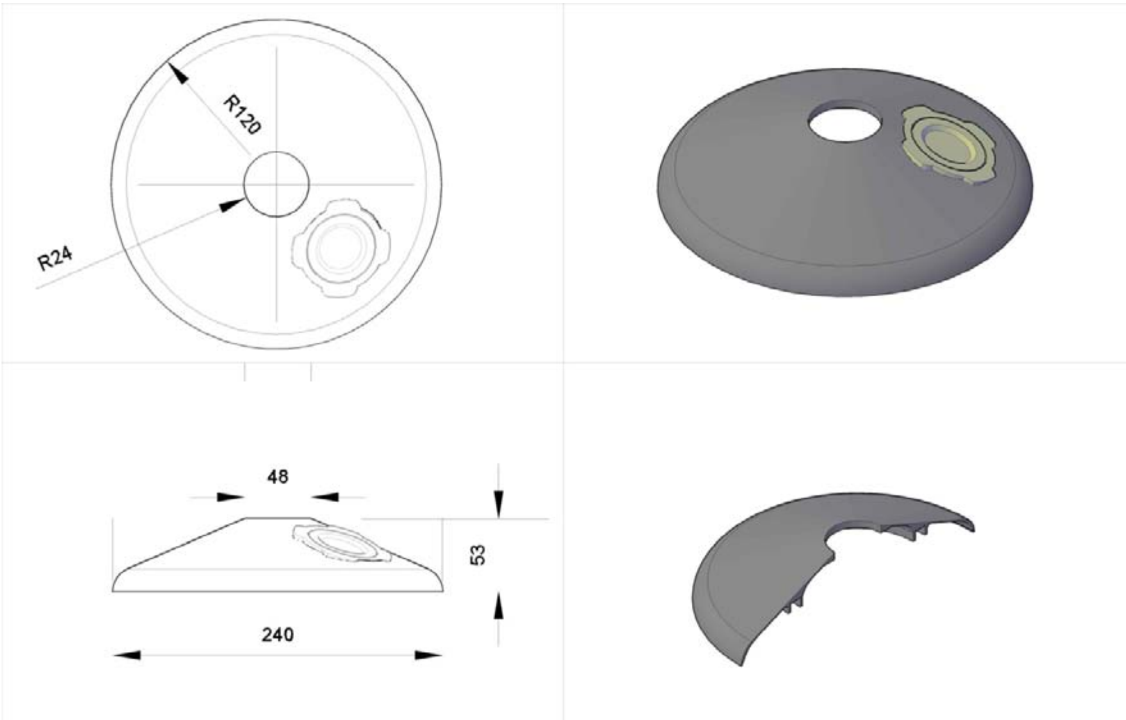


Figure 3.39: 3D model parts for lamp**.**

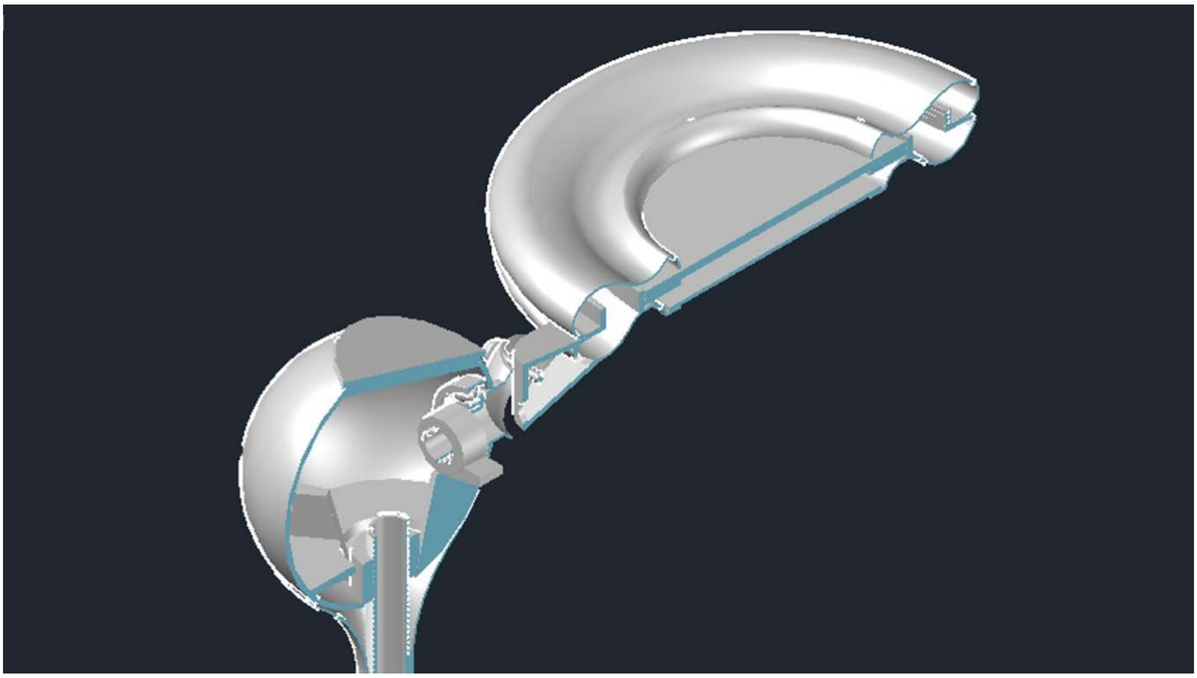


Figure 3.40: 3D model parts for lamp**.**

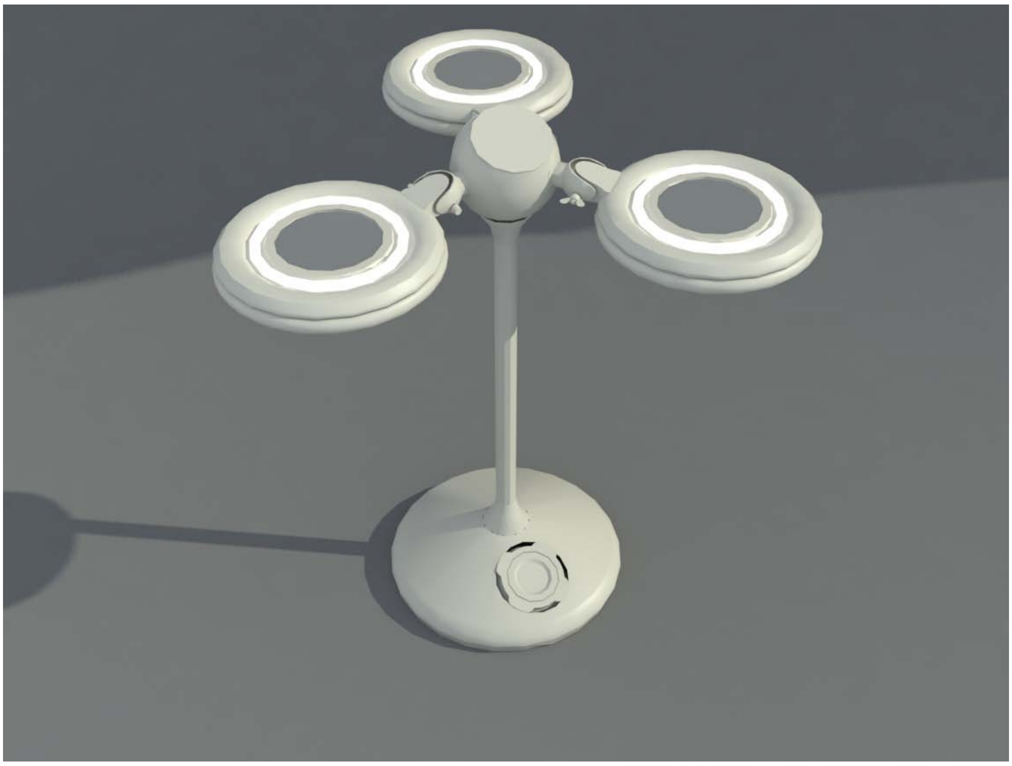


Figure 3.41: 3D model for lamp**.**

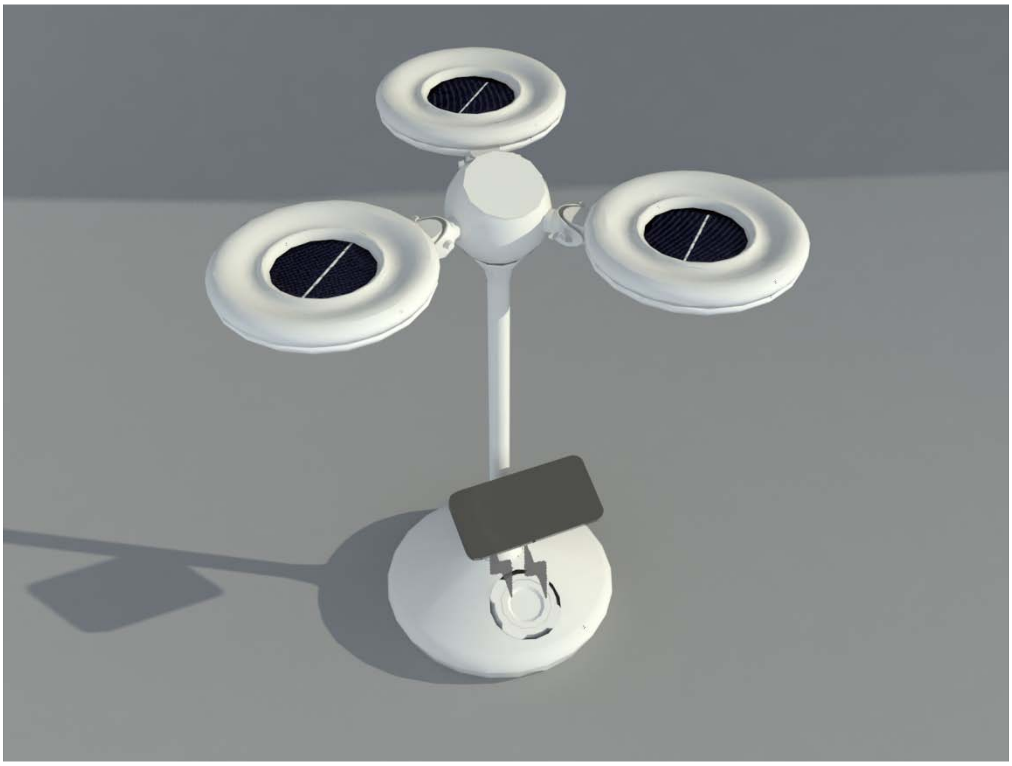


Figure 3.42: 3D model for lamp**.**

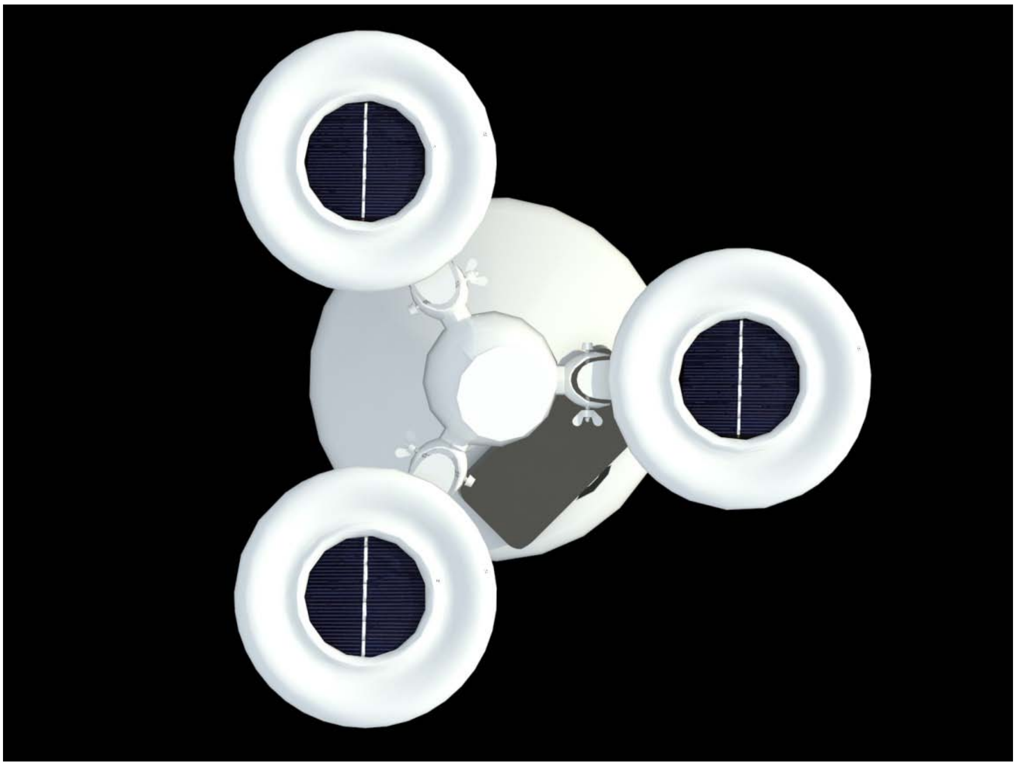
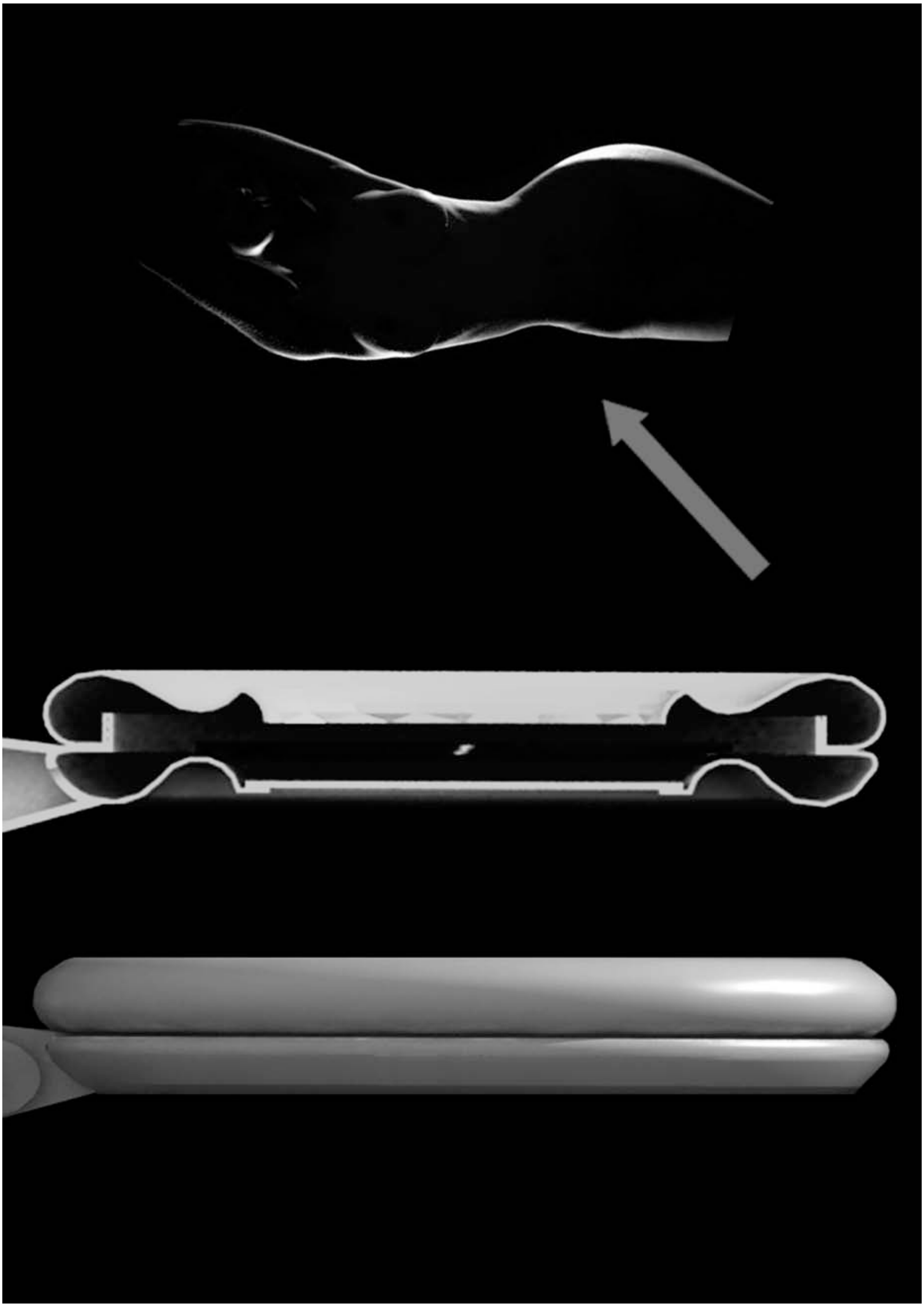


Figure 3.43: 3D model for lamp**.**

Figure 3.44: 3D model lamp



However after consulting with the 3D printing expert we found out that not all of the parts and components could be manufactured with the 3D printing, and that certain parts had to have more durability than the 3D printing could offer. So we decided to make the main frame metallic and to attach the 3D printed parts on the main frame (**figure 3.45 to figure 3.51**).

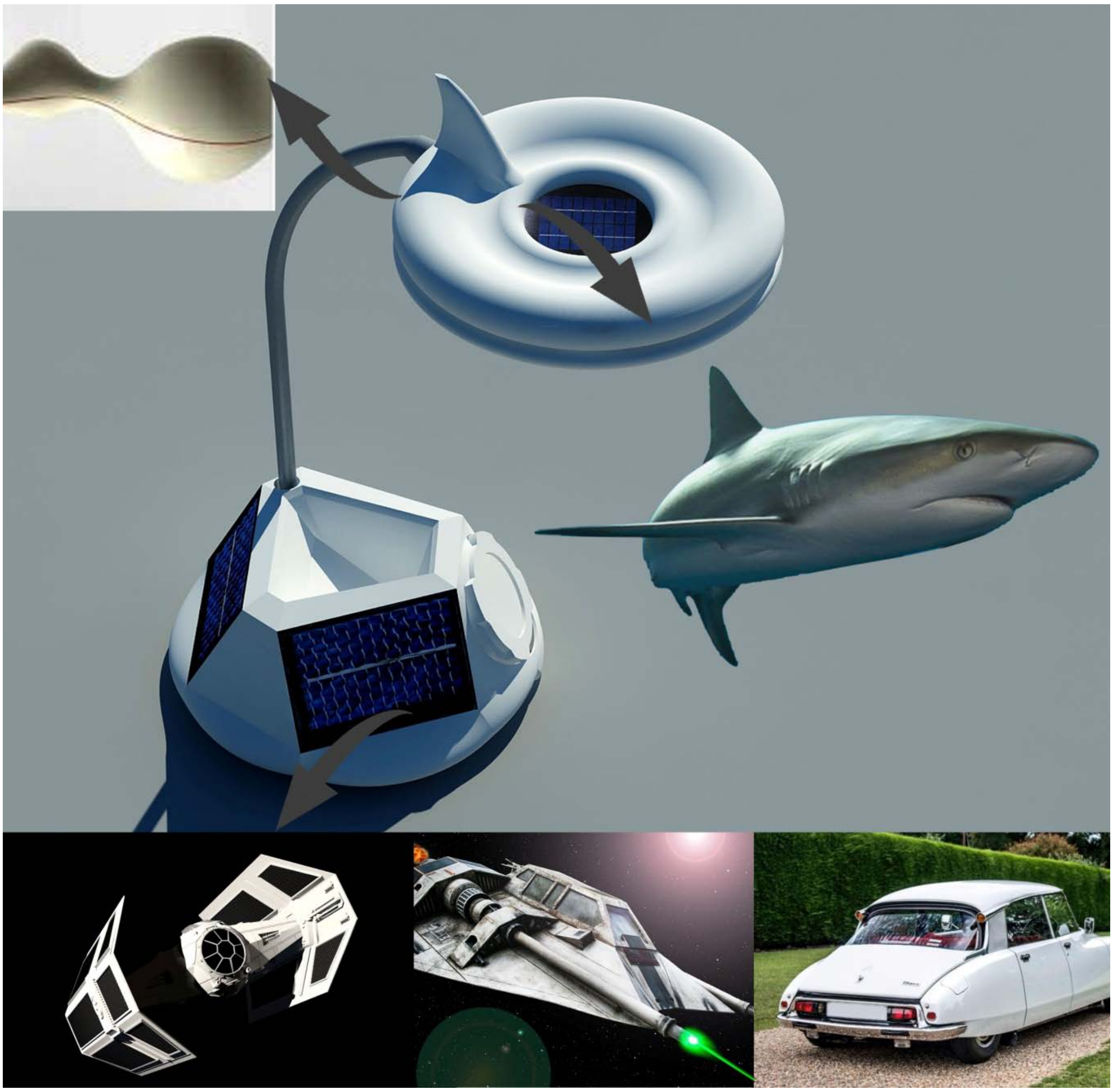


Figure 3.45: Inspiration of shape.

Figure 3.46: 3D model of final version of lamp.

Figure 3.47: 3D model of final version of lamp.

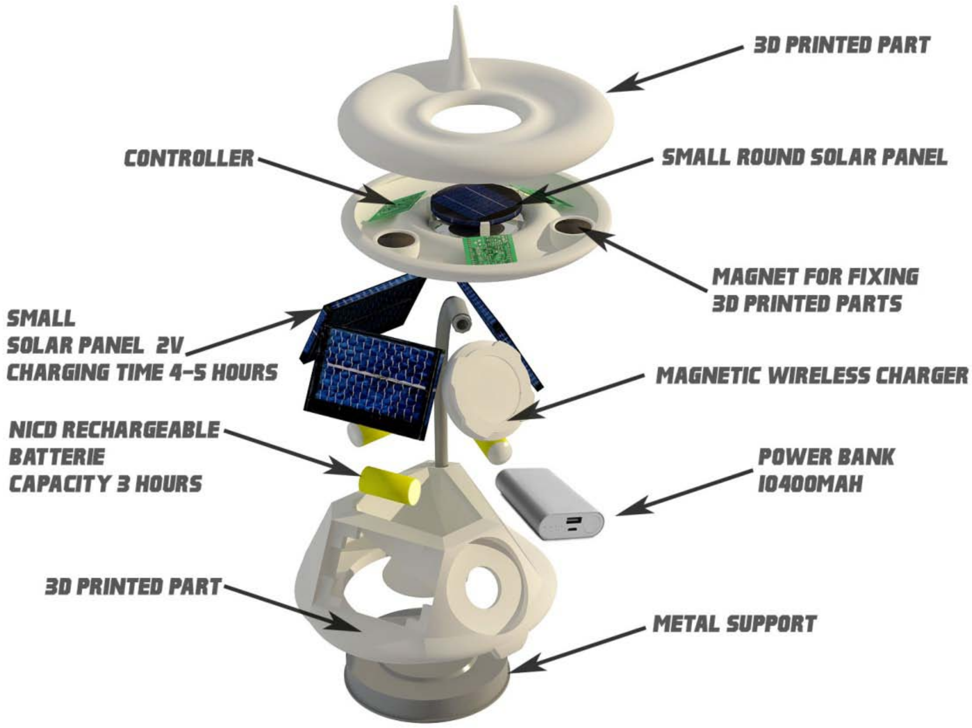


Figure 3.48: Lamp structure.

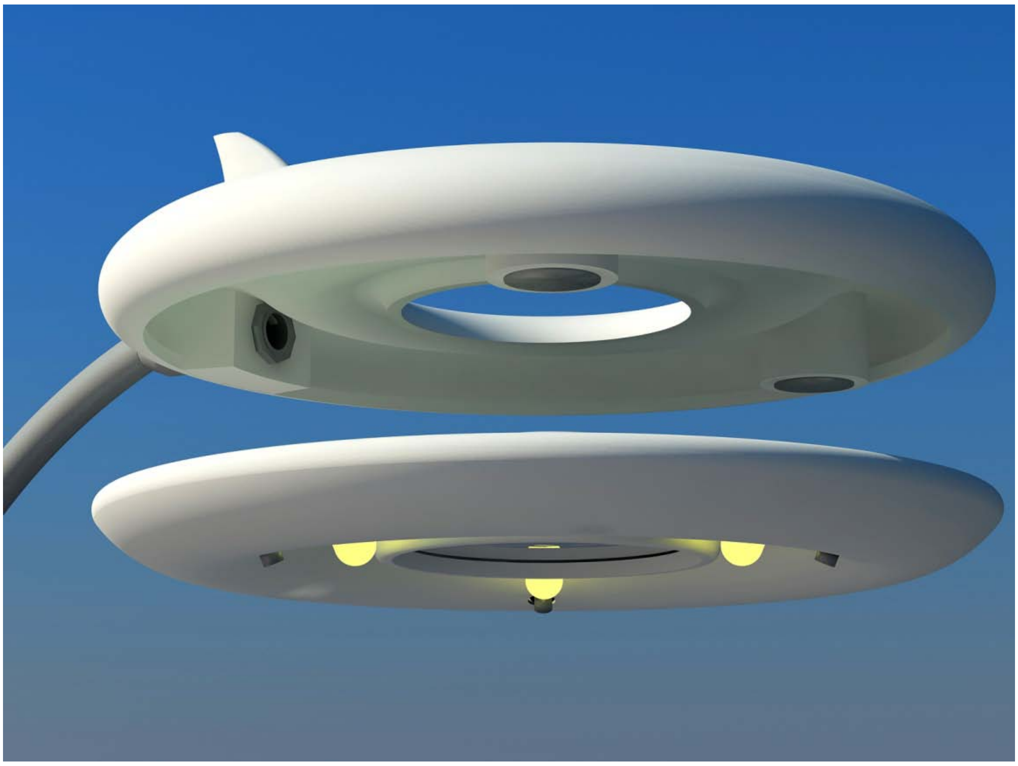


Figure 3.49: 3D model of final version of lamp detail.

Figure 3.50: 3D model of final version of lamp detail.

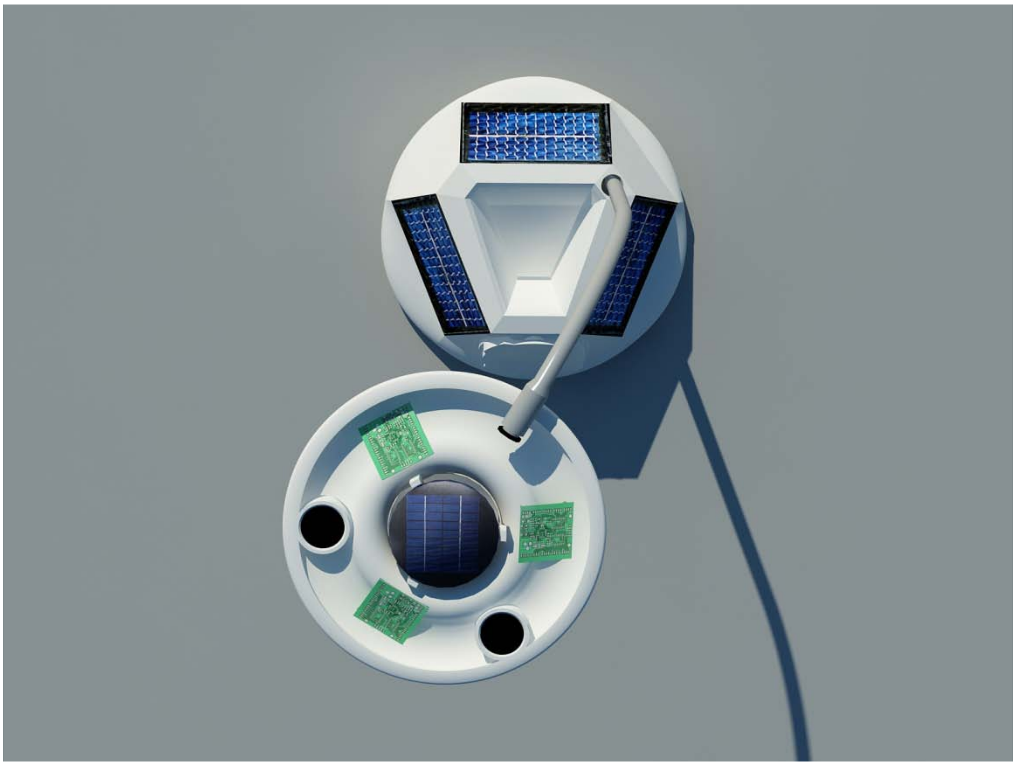


Figure 3.51: 3D model of final version of lamp detail.

Before 3D printing the parts we bought all the other parts and tested them to make sure that everything worked properly as presented in-**figure 3.52**.

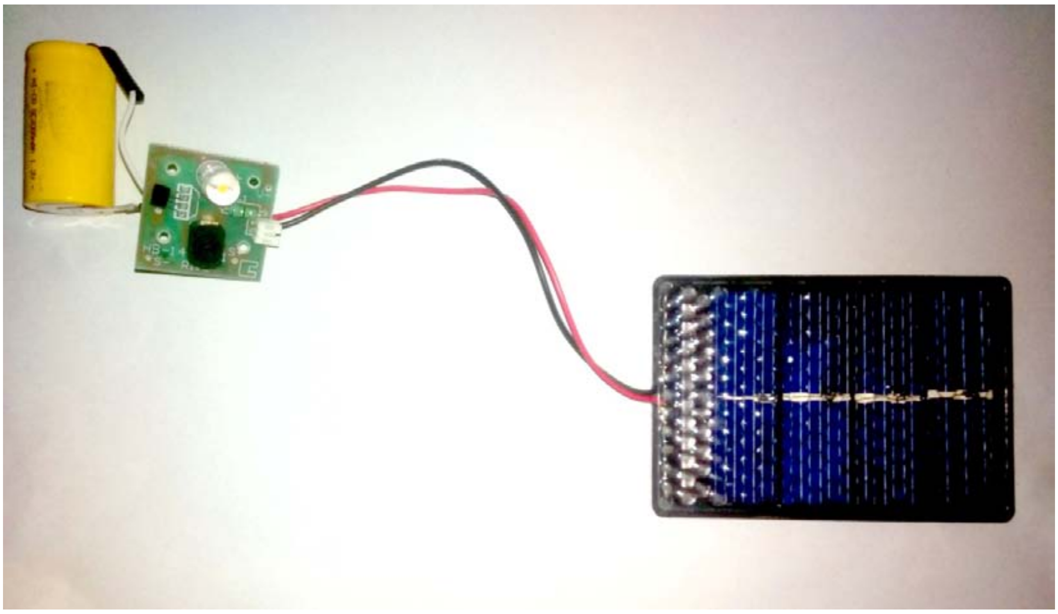


Figure 3.52: Final components for lamp.

Then we did the final touch ups and changes in 3d model designs, **figure 3.53 to figure 3.59,** and had the parts 3Dprinted from ABS (Acrylonitrile Butadiene Styrene) by filament process. We had created a multifunctional lamp with an elegant organic shape which could charge with the solar energy and contained a dock for charging the phone.

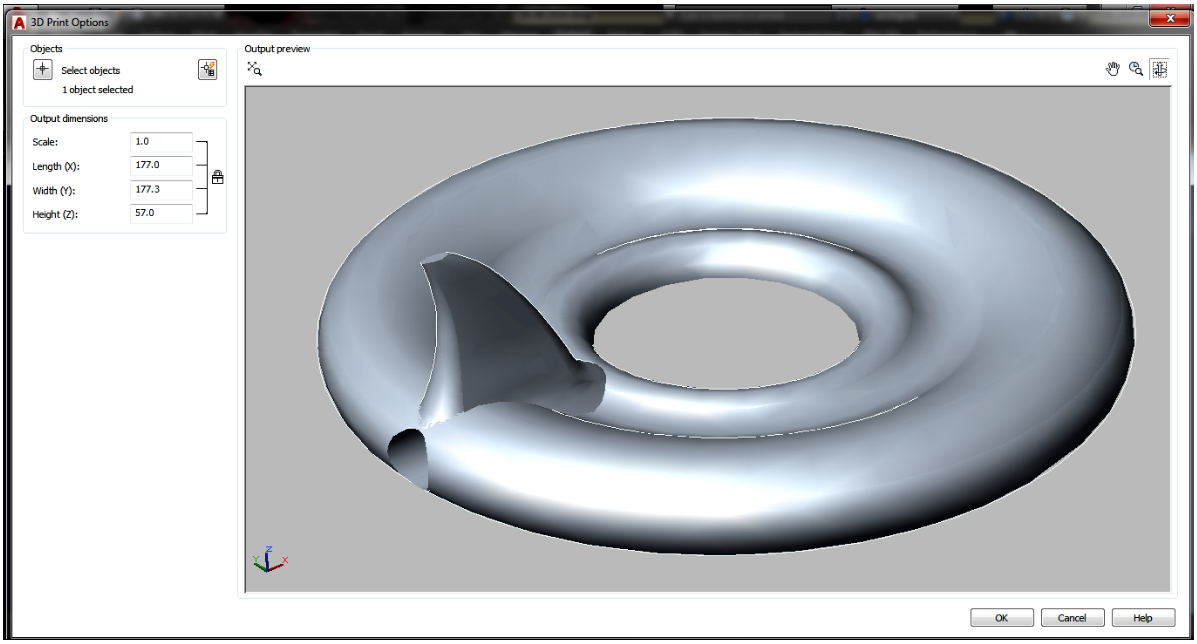


Figure 3.53: Final 3d models for 3d printing

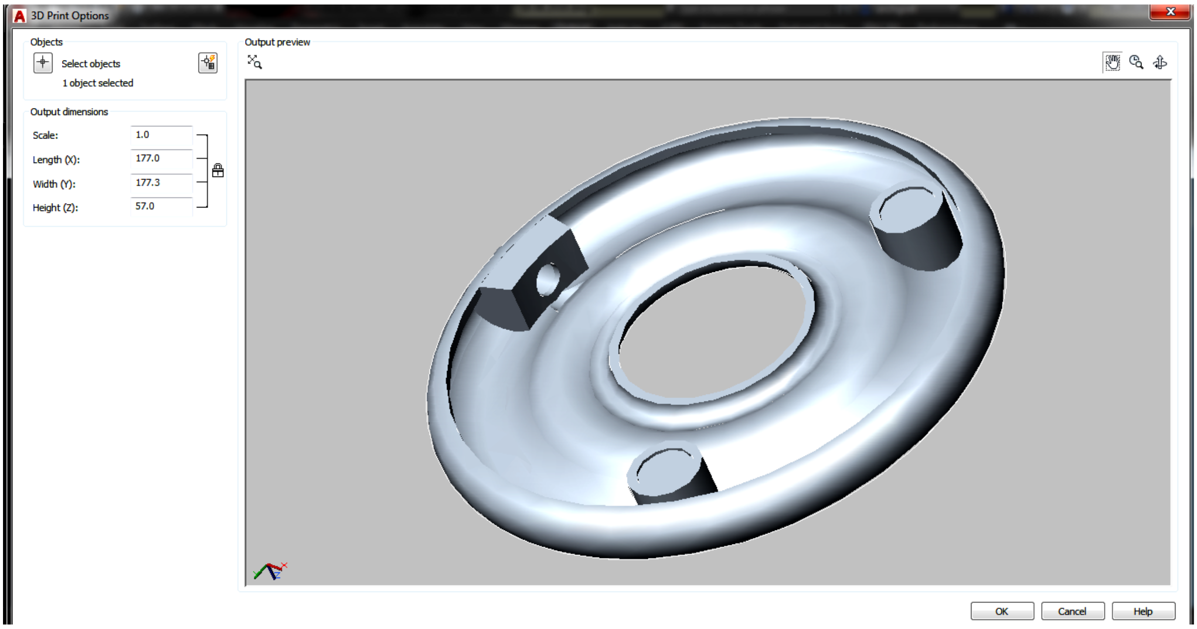


Figure 3.54: Final 3d models for 3d printing

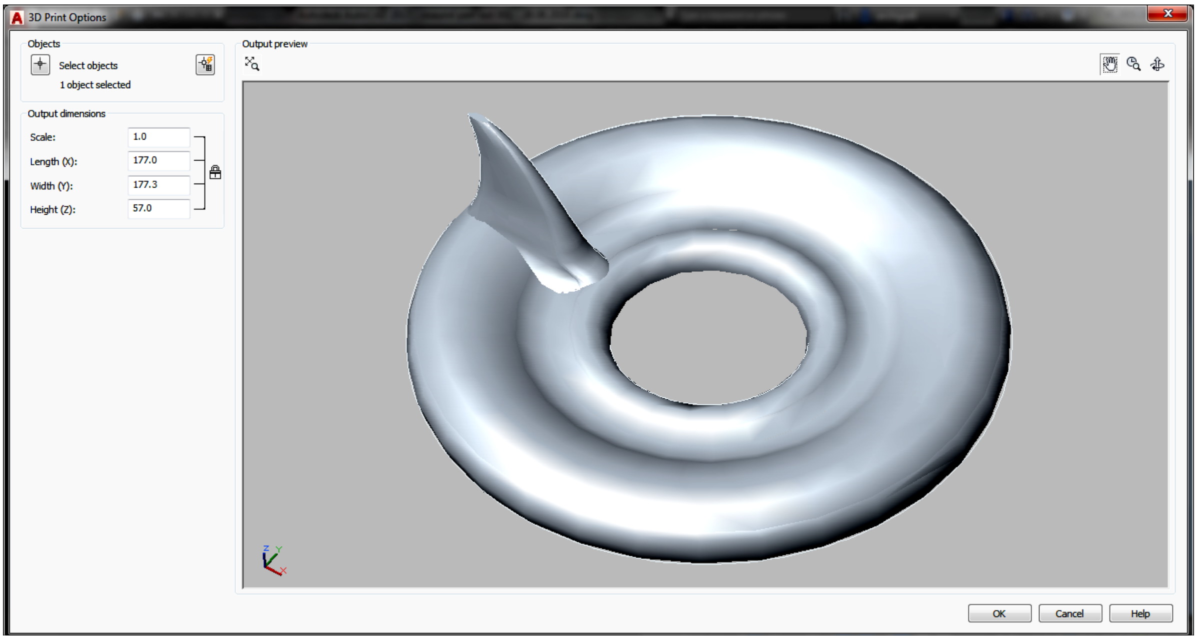


Figure 3.55: Final 3d models for 3d printing

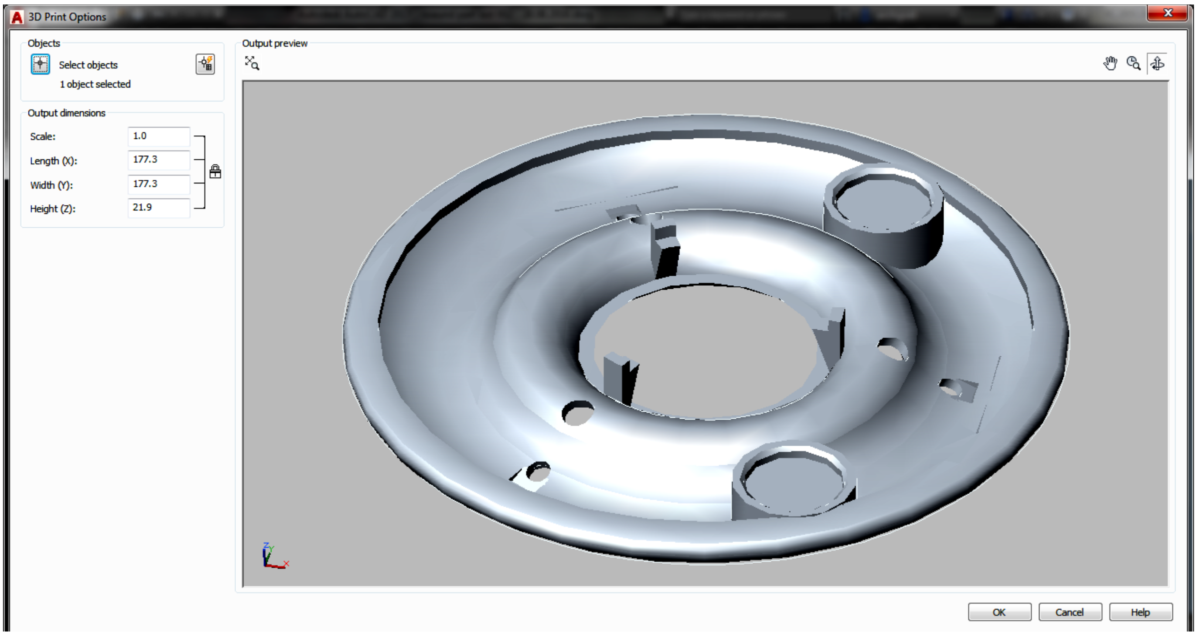


Figure 3.56: Final 3d models for 3d printing.

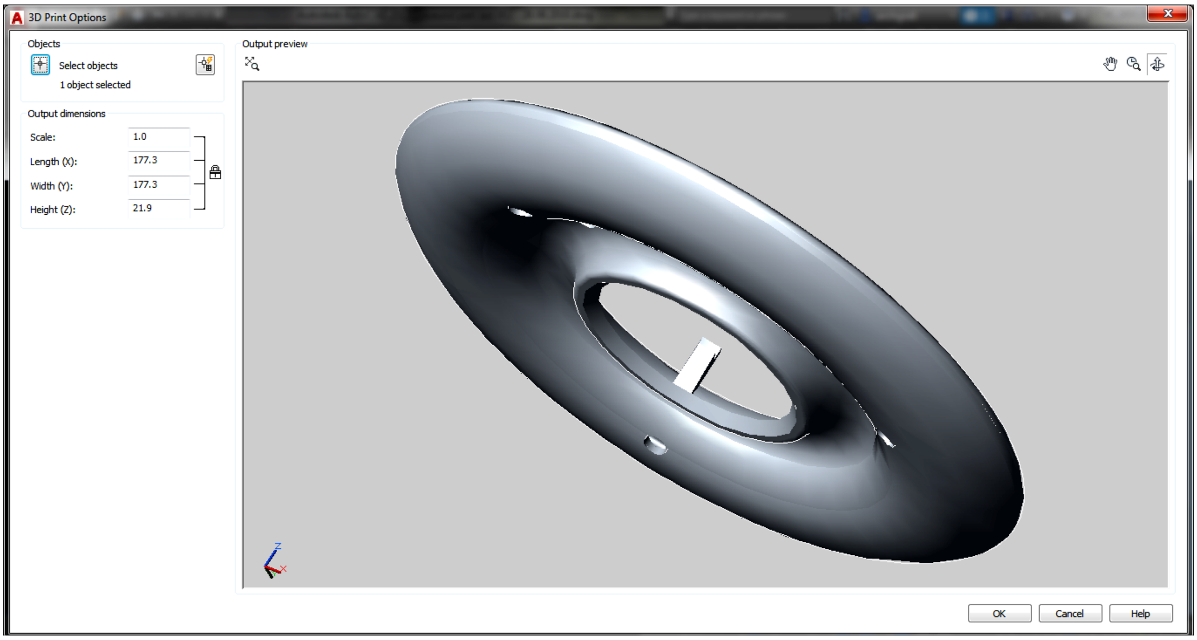


Figure 3.57: Final 3d models for 3d printing**.**

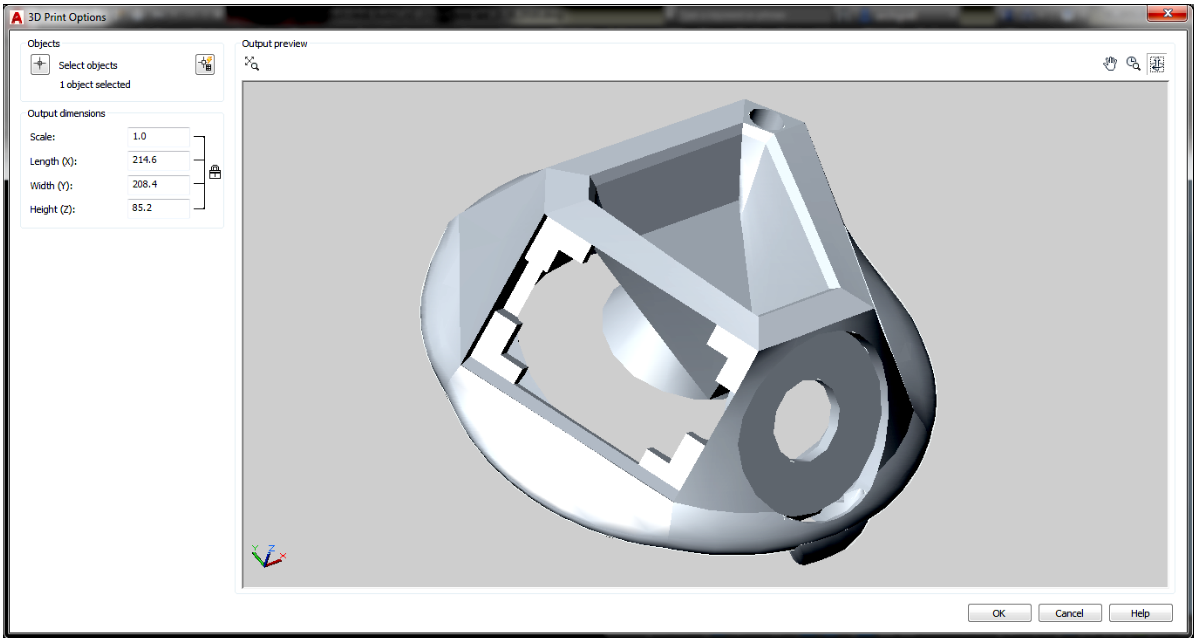


Figure 3.58: Final 3d models for 3d printing

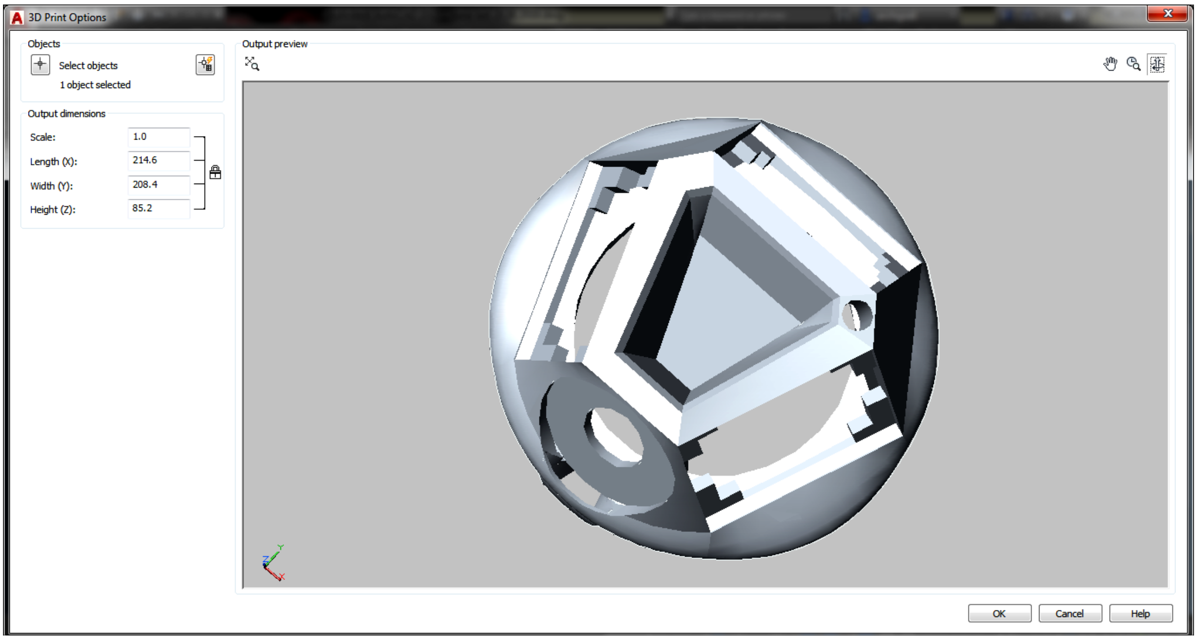


Figure 3.59: Final 3d models for 3d printing

3.2 Prototyping

When the 3D printed parts were ready and all the components were tested with the help of the electrical engineer we started assembling the lamp. The 3D printed parts were easily meshed with each other and with the metal base. The next task was to attach the electrical devices to the 3D printed parts. The mobile charger and the lower solar panels also meshed well with the 3D printed parts without outside help. The only parts that we used the electrical glue for were: LED lights and the controller, only because the electrical engineer advised us to do so. After completely assembling the lamp we tested the lamp and all of its components were working as expected. The lamp is practical and comfortable.

One can see the assembling process and the prototype itself indicated in **figure 3.60** to **figure 3.68.**

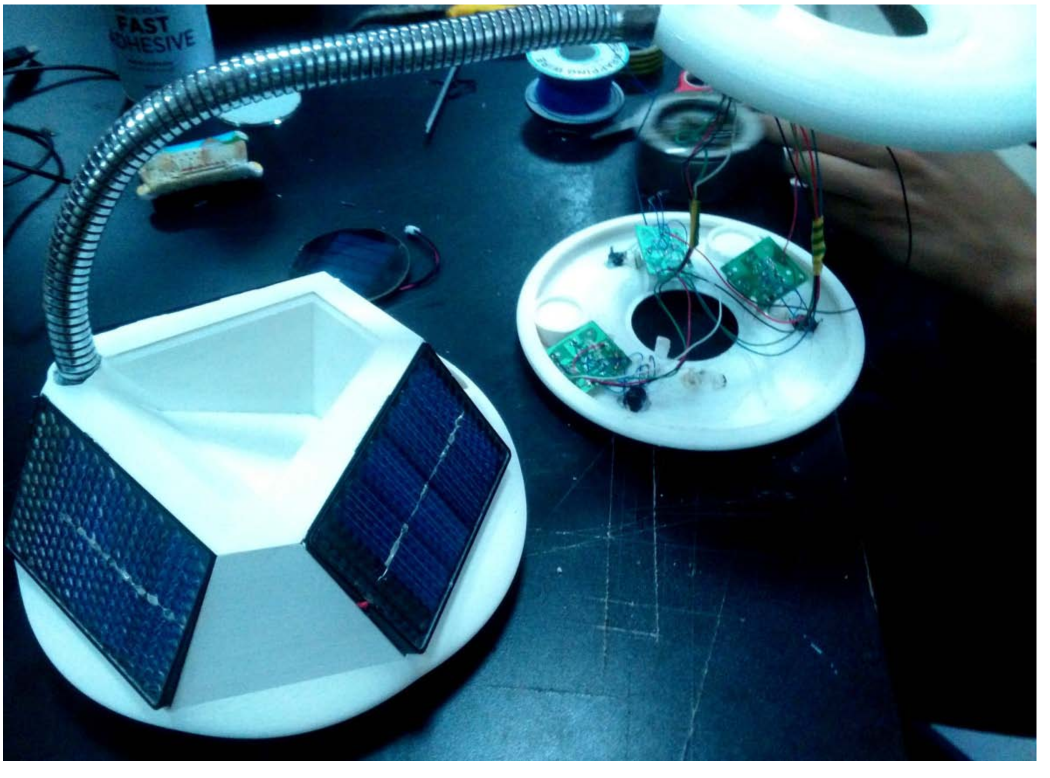


Figure 3.60: Lamp assembling process.

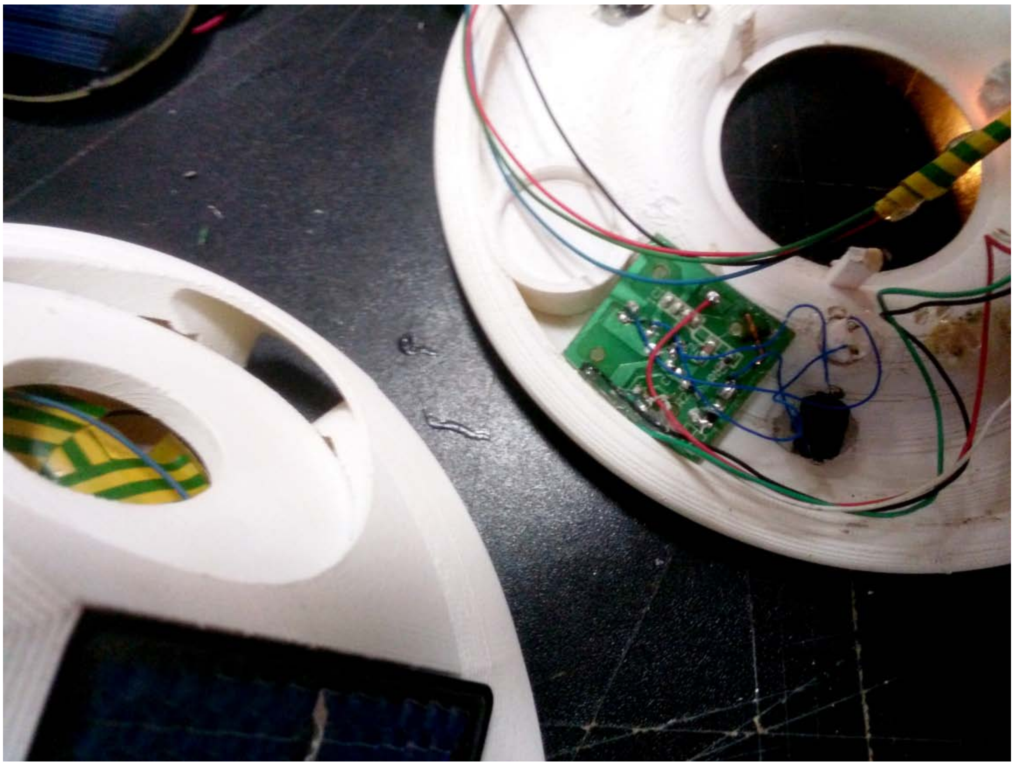


Figure 3.61: Lamp assembling process**.**

Figure 3.62: Solar lamp fully functional prototype**.**

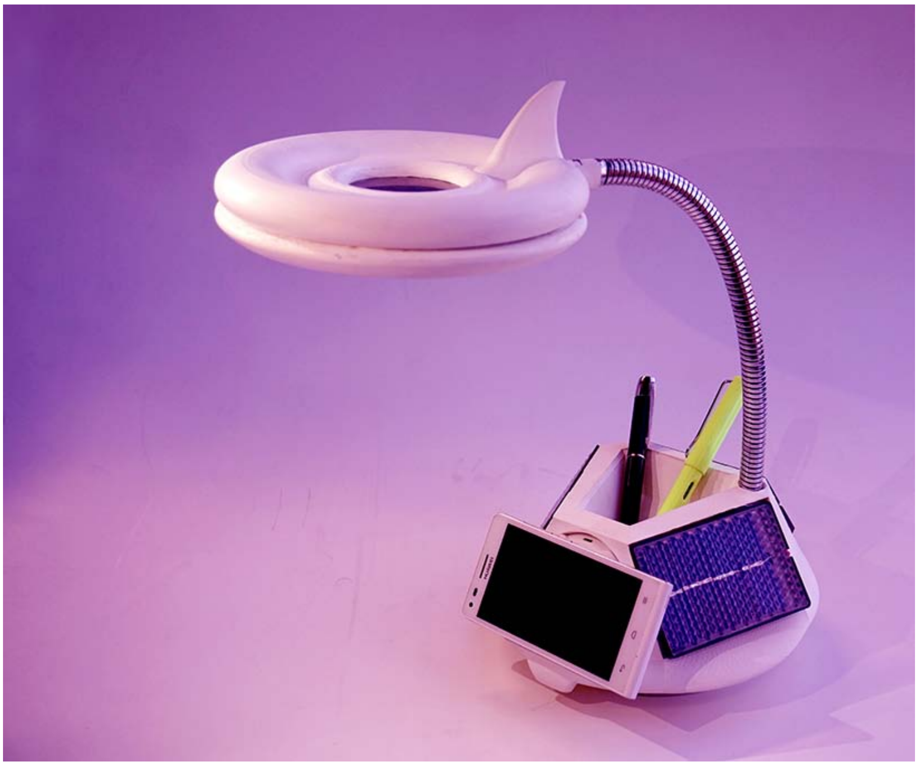


Figure 3.63: Solar lamp fully functional prototype**.**

Figure 3.64: Solar lamp fully functional prototype.

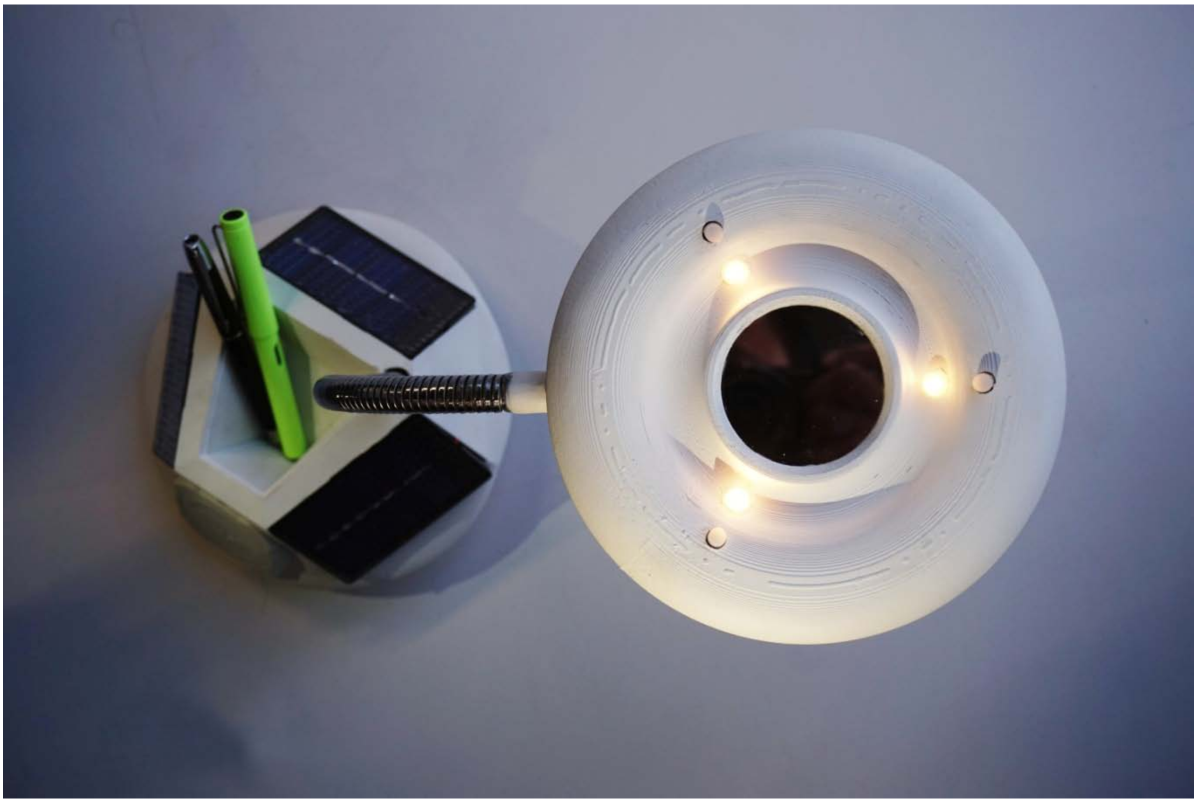


Figure 3.65: Solar lamp fully functional prototype.

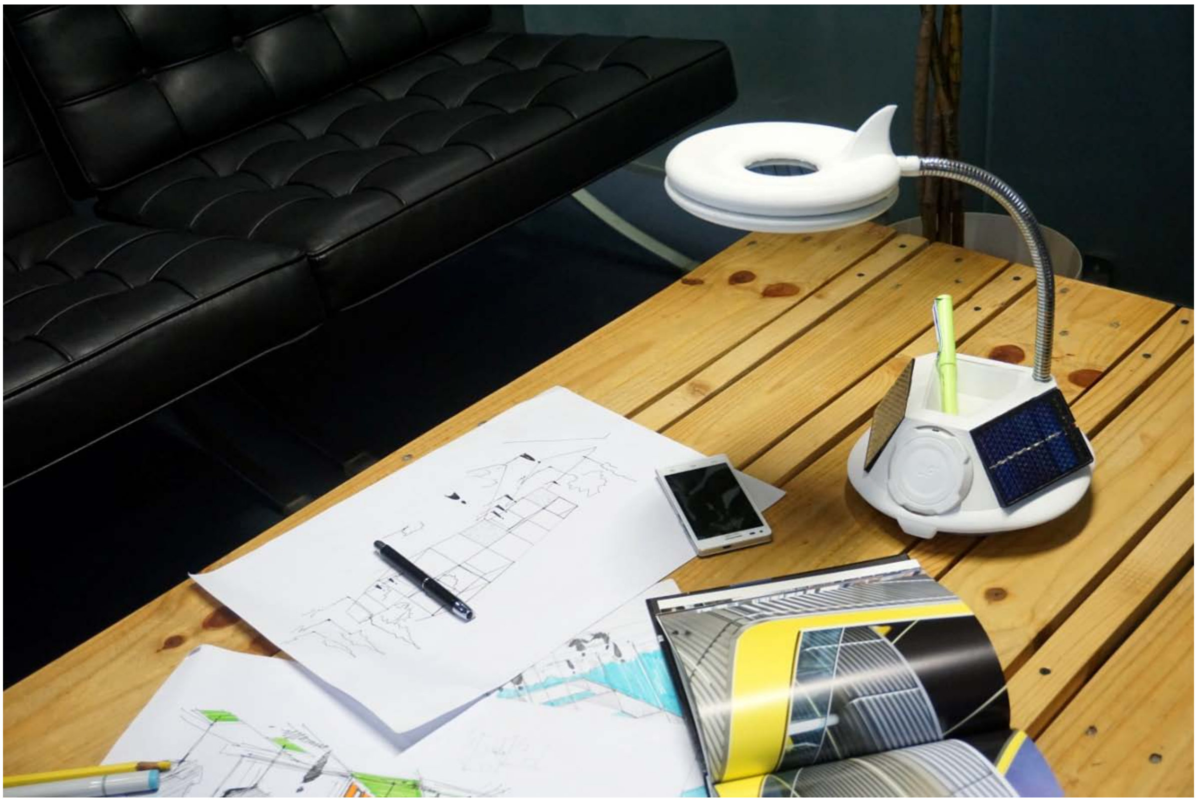


Figure 3.66: Solar lamp fully functional prototype.

Figure 3.67: Solar lamp fully functional prototype.

Figure 3.68: Solar lamp fully functional prototype.

Chapter 4

Conclusions

4.1 Conclusions

The aim of this work was to analyze existing lighting products and try to improve it, make it affordable, more energy efficient and environmentally friendly. In order to achieve that goal the research was conducted of the lighting products which were already on the market. Through the research of the lighting product market, the areas in the design that could be improved were discovered. This information allowed us to identify which were the best ways to develop our lamp concepts during the project development. After deciding the basic concepts of the lamp we researched the components that could be used for the desired lamp. The research of the components for the lamp included the research of the 3D printing, solar panels, wireless phone chargers and rechargeable batteries. After selecting the right components for the lamp we started working on the 3D model of the lamp. We defined all the details of the lamp and before 3D printing the parts we tested all the components to make sure that everything matched properly. Then we did the final touch ups and changes in 3D model designs and had the parts printed.

The objective of our research and experiments was to create a multifunctional lamp that would be unique in its own way. Experiment was finished successfully with help of 3D printing as we created fully functional product which is elegant, practical, ethical, environmentally friendly, energy efficient and multifunctional.

4.2 Future work

At this moment the project is not complete. With the help of the “Fab Lab”, a fabrication laboratory in Republic of Georgia, and its team we continue working on the lamp. We are not satisfied with the current results and have already found ways to make the product even more affordable. We are working to make the product lighter in weight and have discovered several promising ideas for the future works.

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