UCF Senior Design 1

Next Generation Portable Solar Charger

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Group 17

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1. Executive Summary

Phone calls, text messages, emails, and web browsing are all possible through one singular device, our smartphones. People around the world use these devices every hour of every day. However, due to limitations in battery technology, it has become a challenge to keep our smartphones powered on the entire day. There are thousands of research associations and large companies working toward developing the next breakthrough in battery storage technology without compromising the performance. Until that next great leap in technology is achieved, we will work toward improving the ways in which we charge our existing batteries. We can extend the battery life of our smartphones by developing easier and more convenient charging solutions. The apparent simple solution to this battery life issue is to have an external battery pack that can be plugged in and on the go.

To achieve our goal of a more convenient charger, we thought of putting together a portable charger. Portable chargers have become more popular but a lot of them can be bulky, not efficient enough or too expensive. We started by determining our source of power, sunlight, which is an extremely abundant source of energy, especially in the state of Florida.

Choosing solar energy allows us to have a constant, and Earth conscious, source of power for our charger. Solar power has long caught the interest of scientists and researchers as the ideal alternative to fossil energy. Given the abundance of sunlight available to us from our sun, it is logical to want to utilize this energy that has been present since the beginning of time and use it to power our engines and homes.We need a renewable source of energy which can function round the clock without any disruption. Therefore, we need to ensure that the consumer of this charger has stored power to use when the weather is not cooperating - this is especially important considering the amount of rain in Florida or in case of environmental disasters.

Including a battery into this charger will be extremely beneficial to the user because they can charge their phone inside, which is an added bonus for portability. Essentially, our charger will feature multiple solar panels, a battery, voltage regulators (to protect the battery from discharge/overcharge), and a wireless charger (for added convenience). In addition to these main components, we will include an Arduino, a LCD display, and accompanying hardware to allow the charger to display the current power output and battery capacity.

The most important part of this system is ensuring the solar energy we collect is stored safely and properly within the battery. Safety always comes first, and ensuring our battery remains full throughout the day comes second. We will do this by developing a voltage regulator system that limits the amount of charge the battery takes in (to prevent overcharging) and another system that limits the amount of charge leaving through the charger (to prevent discharging).

While convenient and efficient charging is our main goal, we are still striving to make our charger different. We will design our charger around one of UCFs key infrastructures:

the Bounce House. Using the football field as our wireless charger, and the seating as our solar panels, we will produce a solar charger that looks like no other. We are doing this to promote solar energy as an exciting and fun way to support the well-being of the planet.

2. Project Description

2.1 Motivation

The main idea that drove us to this project is that it is one technique of charging that makes use of renewable energy in order to avoid the loss of power and charge. It decreases pollution while also being very user-friendly. In addition, the solar or photovoltaic system is a highly efficient energy source that has had a significant impact on society and industry. People in remote areas have a difficult time charging their devices due to a lack of electricity, so in the future our project could help people in this kind of situation.

Also, we want to make it portable so that users can take it to the beach or any event where they would need their smartphones powered on. Solar energy is a form of a renewable source becoming popular as climate change continues to be a bigger issue in today's world and could bring bigger issues in tomorrow's world. As solar energy continues to become more and more widely available, it not only helps the consumer with saving more money in their pockets, but also pushes the consumer to invest in more renewable resources like solar energy that can help be more environmentally friendly while also preserving the natural environment. As many companies in different industries continue to implement clean energy sources, solar energy continues to be the most popular source to be tested and used in today's products across the market as the sun provides unlimited amounts of energy during the day. We are moved by the idea of solar energy and implementing the best of our knowledge and the hard work through our college career into a project that can demonstrate our teamwork skills as individuals and as a team of engineers.

2.2 Goal

Our overall goal is to build a device that charges a phone and a battery at the same time via solar panels. Additionally, we have other milestone goals we would like to achieve along the way. After we create a system where the solar panels charge the battery, we will switch our focus to charging a mobile device. Our milestone goal here is to use wireless charging to charge the phone. For this, we plan to incorporate a Qi charger to our model. Our next goal is to measure the output power using an Arduino unit, and then display the output on an LCD; this will help the user know how much charge the unit is receiving from the sun. Another goal is to include a separate charger for the battery, one that plugs into a wall outlet for when there is a rainy day or if the panels are not receiving enough sun. Our final goal is to build this charger to look like the University of Central Florida football stadium.

2.3 Related Work

Many companies across different industries are implementing technology toward net-zero carbon emissions or 100% renewable energy. Solar energy continues on the rise as its applications to technology continue to be implemented in today's market across many different industries. From Tesla's Solar Roof, which has many small efficient solar panels represented as a roof, to Anker's Portable Solar Charger, which includes four foldable solar panels that can charge two devices at the same time. As solar energy continues to be a popular option on the rise as a source of electricity for a household. Smartphones are an example of a device that consumes more energy on a daily basis for the average person. As a result, more efficient chargers should be designed in order to consume more clean energy, especially from resources such as solar energy. Technology changes from day to day and even though there are similar projects out there, we plan to have a fun design and a different approach to integrate it. Our project plans to provide a charger used with the Qi standard that can be an affordable option for the average person to use while they would like to charge their device outdoors while knowing that solar energy is charging their device. One of the first things that we decided was on the design of this charger, based on research on similar models we determined, we need to follow the example of an electrical system. It must have a source, a function, and an output. For our source, we will be using solar panels optimized with solar tracking. For our solar panels, we plan to connect them either series to produce a desired output voltage and/or parallel to produce a desired current capability. We have found similar projects where solar panels are used to charge a battery or that connect to an Arduino. One of the problems we find when people work with Arduinos is that it can consume a lot of battery, but we plan to put the Arduino to sleep when not in use or we can also use an on/off switch. Based on our research we also realized we will need some kind of regulator to avoid overcharging it.

Some of the projects we found use a AA battery which would barely output any power, so we plan to modify this and use a bigger battery to make it more efficient and plan to make our project a wireless charging station. Another feature we plan to implement is adding an LCD to display the power output.

Figure 1 shows an existing portable charger that incorporates solar panels, however, the design isn't too attractive. We can also see it uses a Lithium battery and a polymer charger. Also, most of the projects that we researched mentioned having a voltage regulator that we will definitely incorporate in our design. The design in the picture could be portable, but there isn't a case to protect cables or the battery. Therefore, we want to go with something more creative and that even students could take to the UCF's tailgates.

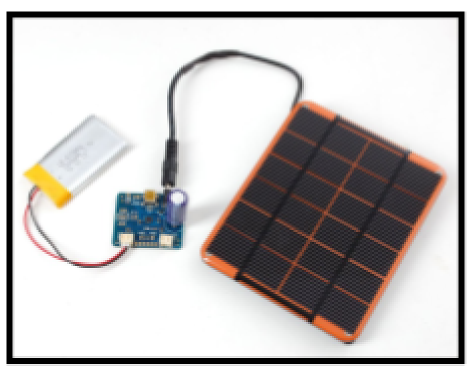

Figure 1. Existing portable solar charger

2.4 Engineering Specification

- The system shall be no longer than 1.5 feet
- The system shall be no taller than 15 inches
- The system will contain a Qi wireless charger
- The system shall not weigh more than 1500 grams
- The system will contain an on and off switch
- The system will contain a solar panel, arduino circuit board, and a battery
- The system will contain an LCD display showing voltage production
- The system will contain a battery to power the system in case the solar cell does not produce enough charge
- The system will be able to be converted into a wall charger
- The dimensions of the solar panels will be 7.7 x 4.9 x 0.08 inches
- The solar panels' ratings will be 9V/3W
- The total cost of the system shall not exceed $600
- The solar charge regulator will have a protection circuit that limits the current being drawn in while the battery is fully charged
- The charger will be capable of charging a 3000mAh phone in 12 hours
- The USB that will be implemented must be able to output a 5V / 200mA output in order to successfully charge a cell phone
- The operation voltage range of the microcontroller will be 7-12V
- The operational voltage range of the solar charge regulator will be the same as the microcontroller
- The LCD display must not exceed 5 x 4 x 3 inches (Length/Width/Height)
- The system's electrical components shall be weatherproof
- The secondary battery shall be a lithium ion battery
- The secondary battery shall be rated 12V
- The secondary battery shall be no bigger than 4 x 5 inches
- The secondary battery shall weigh no more than 100 grams
- The secondary battery will have a rating of 9V
- The arduino software will read the amount of voltage being produced by the solar panel and display it on the LCD board
- The Qi wireless charger PCBA's dimensions will be 3.2 x 3.2 cm
- The Qi wireless charger will be 5 cm in diameter
- A button will be included to read the battery's percentage, displayed on the LCD screen
- An LED will light up whenever there is a cell phone connected to the charger
- The 3D printed foundation will be made of PLA (Polylactic Acid)
- The field inside of the stadium foundation will be made of artificial turf
- AutoCAD will be the software that will be used for the design of the system
- The solar panels will be attached to the foundation using hot glue

2.4.1 Objective

In order to produce enough power to charge a phone, the solar cell must have a sufficient light source to activate the photoelectric effect. Sunlight hits the photovoltaic panel, and the photons energy breaks electrons free from the silicon semiconductors. This creates an electric field, providing DC electricity to the Arduino, which theoretically will regulate the amount of current going through the battery and charger. We may have to build the regulator ourselves. Furthermore, we'll encode the Arduino board to read the battery percentage and display it on the LCD.

2.4.2 Components

The table below shows each component we will need in addition to their individual specifications such as dimensions, support capabilities, etc.

Components	**Specification**
Dimension of the charger	> 6.33 x 3.07 x 0.29
Overall dimension	**TBD**
Battery	Lead-acid battery
Solar panel	Small solar panels, might need to be curved
Devices supported	Mobile phone, iOS / Android
Charging connectivity	Wireless Qi charger
Power Output	> 5 - 7.5W, depending on device
LCD Display	Display power output
Arduino Kit	Circuit Elements and Design
3D Printed Stadium Model	Acts as a foundation for the solar panels to rest on
USB Cable	
On/Off switch	Turn on/off our charger

Table 1. Components Description

2.4.3 Battery Considerations

The project will require energy from the sun to the solar panels and convert it to alternating current voltage, which can power most mobile phones. The project should include a system for monitoring voltage levels and protect the system from being overused or overcharged. A lead - acid battery should sufficiently meet the charging requirements that are necessary to power a 5-7.5W wireless Qi charger. The charge regulator should meet the specifications necessary to maximize charging efficiency. We must also incorporate discharge protection to the battery, since keeping the battery from draining from the solar panel will be an important precondition. Furthermore, since solar panels are a relatively inconsistent form of power generation due to cloud cover, temperature, and light source (sun) position, this will create the need for a charge regulator circuit that will connect between the battery and the solar panel. Another regulator we'll need is a voltage regulator so that we can limit the amount of current being passed to the battery to avoid damage. Moreover, the regulator will make sure that a constant charge to the battery is maintained while the solar panel is exposed to sunlight, and power will be supplied to the Arduino microcontroller. Power to the microcontroller may require a step-down component, and the microcontroller will regulate the LCD display.

2.4.4 Overall Design

This charger is designed to look like the UCF Bounce House. The stadium is shaped like an oval; the longer sides will each feature a solar panel to charge the battery. One of the shorter sides will feature an LCD display that will show the current output power as well as the battery percentage. The other shorter side will have the on/off switch for the device. The wireless charger will be placed underneath the center of the football field. Underneath the bleachers and the field, we will store the battery, arduino, voltage regulators, wires, and other additional hardware that makes our charger work. The structure of the stadium will be 3D printed from PLA plastic filament. The football field will be made from artificial turf.

Figure 2. 3D Printer

2.4.5 Stadium Construction

We decided to use a 3D printer to build our model stadium to ensure our solar charger had the most accurate appearance. There are many benefits to 3D printing including light weight, cost effective, durable, and detailed. The 3D printer we chose uses a PLA (Polylactic Acid) filament which is a lightweight and durable thermoplastic; additionally, PLA filament is made from renewable resources such as corn starch, tapioca roots, or sugar cane, which furthers our commitment to truly green energy. These resources ensure that PLA filament is extremely cheap due to how easily attainable they are; this allows our team to bring the cost down of our project, and make it available to more people. 3D printing also allows for an extreme level of detail. Thanks to modeling software available on our laptops and/or desktop machines, we have the ability to create a very accurate and precise model of the Bounce House.

The printer we have chosen to use is an old printer from a team member's high school years - it is called the da Vinci Mini. This printer was made by XYZPrinting, which is a part of a global manufacturing group based in Taiwan. Their main goal is to produce affordable and easy-to-use 3D printers. This exact model is not an industrial printer, and was designed for lower level designs. With this in mind, we still will have an accurate design, but we do not expect perfection; if we had a larger budget and more time, we would consider a more industrial-based printer. The stadium will have to be printed in multiple pieces due to a limited print size for our 3D printer.

The stadium will be designed using a software solution by XYZPrinting. They offer multiple tools for viewing and printing, as well as for editing. However, if we are not satisfied with the level of detail, we will move to more complex programs such as AutoCAD.

2.4.6 Arduino Connections

This section will be completely finalized after testing has begun. At this moment, our main goal is to ensure all of our components are at the same voltage (9V). We chose 9V because it is in the middle of the Arduino range of operation (7V - 12V). Ensuring all of our components have the same voltage will allow us to accurately measure, record, and display the voltage being output to our wireless phone charger. Essentially, our design will feature multiple solar panels in series connected to a battery charger. This will start the parallel connections: battery, usb charger (phone charger), arduino. The arduino will be connected to a potentiometer via a jumper cable. Additionally, jumper wires will then be connected to the 5V and GND connections on the Arduino. This is the hardware setup required to measure the incoming voltage into the Arduino (the rest will be done via code implemented through the Arduino IDE). Since all of these components are in parallel, the measured voltage at the Arduino will also be the measured voltage at the battery and at the phone charger. This will allow us to display to the user (on the LCD panel) what the current voltage output is. This is important in determining how much sunlight the panels are receiving as well as how fast our phone will charge.

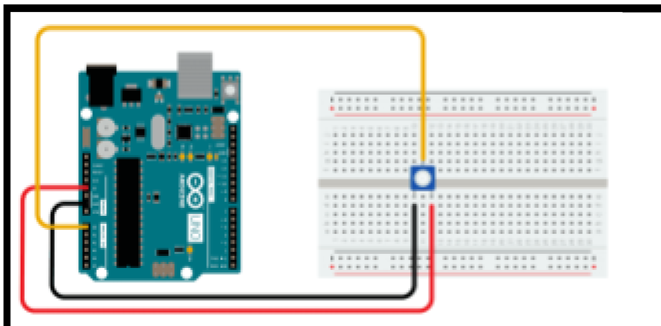

Figure 3: Arduino Voltage Measurement

2.4.7 House of Quality

The tradeoff matrix is depicted in *Figure 3* as a House of Quality diagram. This matrix shows the tradeoff between various aspects of the design specifications and requirements. Some of the marketing requirements that we added are a set of needs and desires from the consumer's point of view. This includes things like price, which consumers want to be as low as possible. Also, as a team, we want the cost of production to be as low as possible while keeping efficiency and quality as a priority. Another criteria was battery life, which users prefer it to last as long as possible.

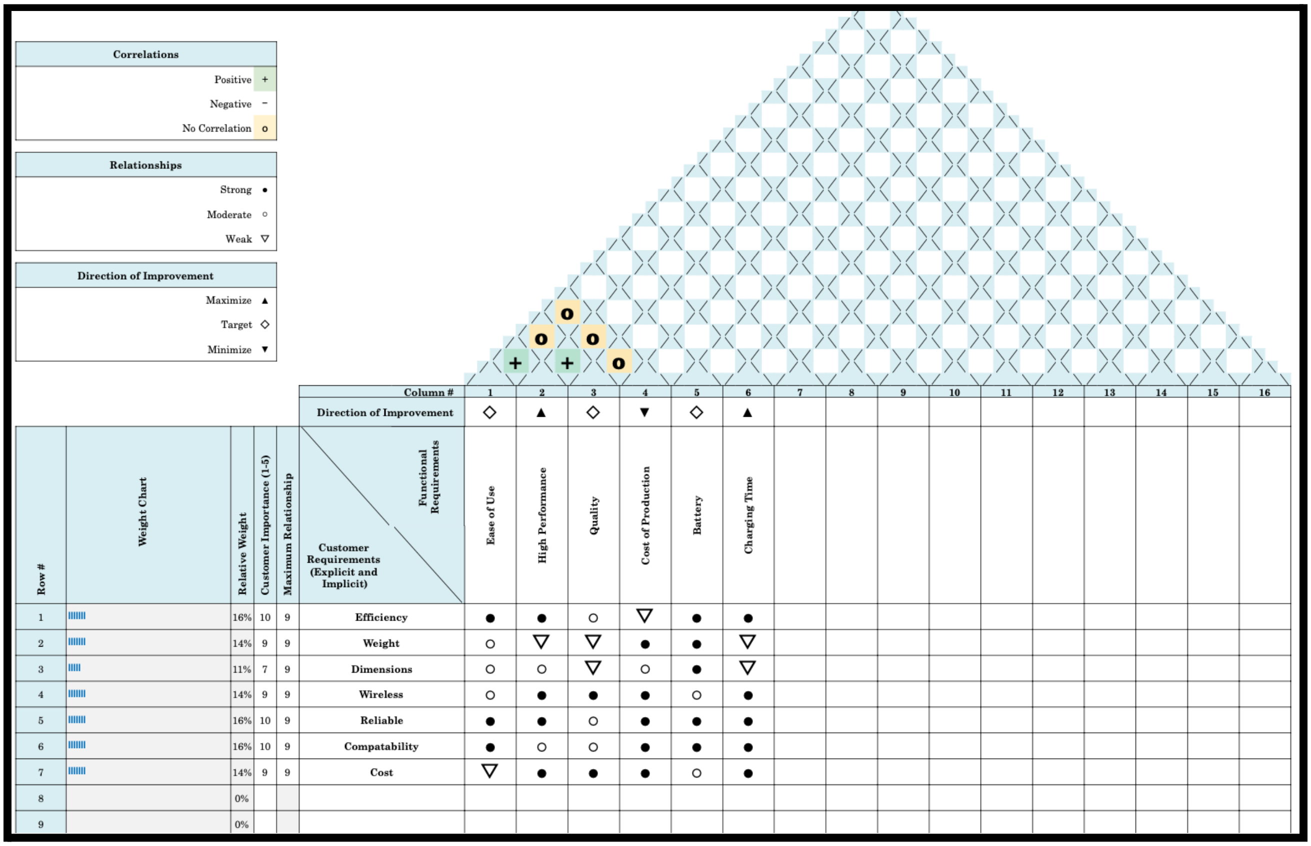

Figure 4. House of Quality

2.4.8 Constraints

The portable solar charger might include various hardware and software constraints that need to be addressed and looked at during and after the building of the prototype. Each constraint needs to be evaluated individually at first, and after they all have been looked at, the complete set of constraints are applied to the design. All constraints need to be realistic and look at other constraints within them.

The cost of designing the project will be a major constraint since we do not have a sponsor. All the expenses will be covered by the team members. This will limit the part selection and possibly the quality of the parts.

One manufacturing constraint to consider is the availability of the chosen materials. In addition, some parts can get damaged during our prototype building stage and when we test connections using a breadboard. We are planning to get extra materials to account for damaged parts and testing, but we could run into a situation where we don't have enough parts and will have to wait to order new ones.

For environmental constraints, even though renewable energy seems to be environmentally friendly, we have to think on what to do with solar panels when they break. Solar modules can currently be disposed of in the same manner as other types of e-waste. Countries that lack robust e-waste disposal infrastructure are more vulnerable to recycling-related issues. However, this shouldn't be a problem for the size of our project.

Our project should be easy to use, however, sunlight is not always available. Solar energy can be a drawback since we don't have access to solar energy at night or whenever it is raining, requiring us to store excess energy made during the day for later use or have an alternative connection as a power source.

Moreover, we expect this to have a reasonable weight and size, but it will all depend on the amount of solar panels that we end up using. We will have to look at the amount of energy that one solar panel outputs and based on that we will determine how many solar panels to use and the size of our 3D printed design to hold our components.

There are also time restrictions that we have to keep in mind. We have a couple of deadlines set in order to complete our project. Our paper and prototype design has to be done by the end of Senior design 1. We have to finish our project by the end of Senior Design 2.

2.5 Block Diagram

The block diagram in *Figure 4* serves as an overview of how we will connect our electronics and our design process. We start by describing the relationship between the energy input, the sun, and the battery. We will get the energy through the solar cells and it will be sent to the arduino.
We also listed some of the actions we will take to complete the project such as designing in AutoCad, creating schematics, and testing connections in a breadboard.

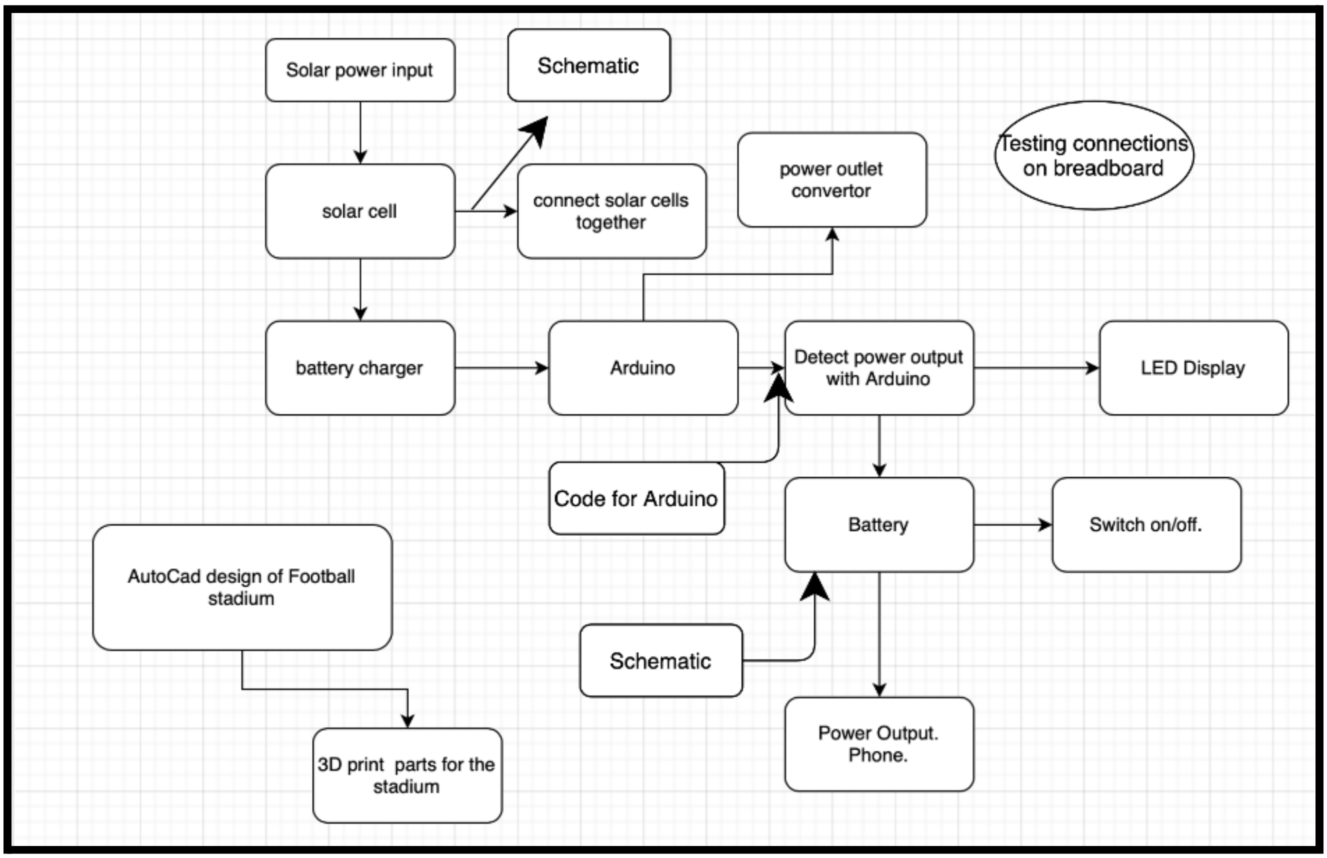

Figure 5. Top level project design

Roles:

- AutoCad & 3D Printing: Tyler, Conner
- Code: Leslie
- Schematics: Luis
- Testing and building: All

2.6 Estimated Budget and Financing

Below is the estimated budget and financing for the project. Our goal is to limit the overall cost of production, we are hoping to not exceed $600 and be as cost effective as possible. We are hoping to have some solar panels donated to reduce costs and we will work with some components that we already own. These prices are estimates and may change in the future once we start putting things together. We might also need to test some of these components and buy extra materials for testing purposes.
We don’t have a sponsor for the project so all of the costs will be covered by the members of the team.

Each Team Member: $150
Total Budget: ~ $600

Components	**Price**
Solar Panels	$60 - maybe donated
Circuit Elements	$20
USB Plug	$5
Qi Charger	
Arduino	Owned
LCD	Owned
ON/OFF switch	$2
Voltage Regulator	$1
Breadboard	Included in arduino starter kit
Battery	
3D Printer	Owned
3D printer filament	$20 - $100

Table 2. Budget Table Setup

2.7 Initial Milestones

The following milestones and due dates will be spread out from the beginning of Senior Design 1 semester to the end of Senior Design 2. This will ensure that our project is completed on time and our goal is met. We set these milestones in accordance with the team member's schedules and responsibilities. The majority of the milestones in the first part of the project are based on research and familiarization with the project and system's components. The dates on each will vary and some might need more time and dedication from the team.

- Senior Design 1:
  - Project Idea Discussion
  - Project Selection and meetings setup
  - Role Assignment
  - Design Document setup and access for all members
  - Project Report: Divide and Conquer Part 1
    - First Draft - 10 pages
    - Initial Idea Description and Motivation
    - Research on similar projects
    - Initial Specifications
    - Document Review w/Dr.Wei
  - Divide and Conquer Part 2:
    - Complete initial 10 pages
    - Discuss project specifications
    - Design House of Quality
    - Set table of contents
    - Discuss further design specifications
    - Set up a list of materials and their costs
    - Research, Documentation and Design
      - Solar panel
      - Power supply
      - Regulators
      - Order materials and parts
      - Design/sketch solar charger
      - Create the schematic diagrams
  - Test project materials and start putting it together
- Senior Design 2:
  - Testing prototype
  - Redesign if necessary
  - Finalize prototype
  - Finalize documentation
  - Final presentation

3. References

Ada, L. (n.d.). *USB, DC & Solar Lipoly Charger*. Adafruit Learning System. Retrieved September 30, 2021, from https://learn.adafruit.com/usb-dc-and-solar-lipoly-charger.