Solar Powered XO Laptop Design

APSC 100 Module 1 Project Proposal

By

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Report Prepared for

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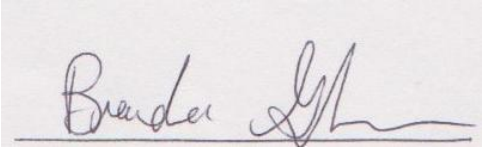
Honesty Statement

"Our signatures below constitutes our pledge that all of the writing is our own work with the exceptions of those portions which are properly documented"



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Brendan Graham

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October 19, 2009

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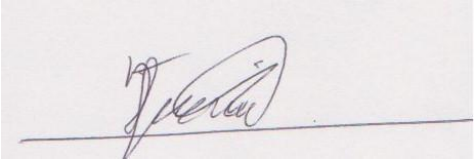

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Qaseem Jiwani

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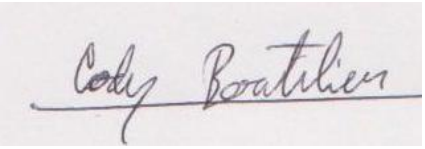

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Executive Summary

The non-profit organization OLPC (One Laptop Per Child) is looking for a cheap and effective way to power their laptops. One of the ways to obtain this power is though solar power. About 15 watts of power must be outputted through a solar panel that is connected to the laptop, and this solar panel cannot be more than $80 in price, nor can it be too large to comfortably carry around with the laptop.

The problem is that this laptop is to be distributed to children in 3rd world countries who do not have a lot of money. Many of them do not have the access to electricity to charge a laptop, which is why if it was solar powered this would be of much help to them.

The solution, therefore, is to create a solar panel that can be connected to the laptop. This way it can use the solar energy of the sun and convert it into electricity to run the laptop, and this would take out the necessity charging it though a plug-in.

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List of Figures and Tables

1.0 Introduction

The first task necessary was to research about what the XO Laptop actually is. It is a $100 subnotebook computer, and it is meant to be distributed to children around the world in developing countries. The point of doing this is to give them opportunities that they may not have had before. It can also connect to the internet, which gives them a great chance to expand their knowledge. It is small, which is convenient because children sometimes have to walk large distances to get to school. This laptop is inexpensive, which is important because many individuals in developing world countries do not have lots of money. It is also very durable, energy efficient, and is readable under direct sunlight for children who go to school outdoors. An important aspect of research into this laptop was that it takes approximately 15 watts of power to run, which is important when determining the right solar panel to use for it.

The next task was to research what a solar cell actually is, and how it can be used to run the laptop. A solar cell is a device that creates electricity by converting the energy of sunlight directly into electricity. Groups of these solar cells are used to make solar panels. Energy created this way is called solar power. Most solar panel models use wafer-based crystalline silicon. There are silicon parts of the cell, with electrons filling up most of the holes in between them to balance out the charge. Right at the junction, the free electrons mix and form a barrier, making it difficult for electrons on one side to cross over onto the other side. Eventually equilibrium is reached, and this causes an electric field to separate both sides. The electric field acts like a diode, and it lets electrons to flow from one side to the other, but not vice versa. When photons of light hit a solar cell, its energy frees electron-hole pairs. This causes a disruption of electrical equilibrium, and if an external current path is provided, electrons will flow through the path to their original side to join with holes that the electric field sent there, doing work along the way. The electron flow provides the current, and the cell's electric field causes a voltage. Because this contains current and voltage, power is also obtained (because it is the product of the two).

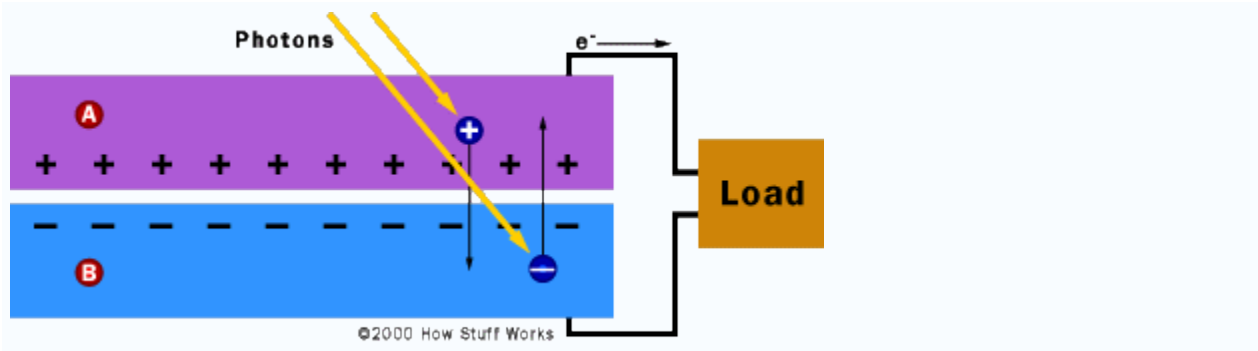

Figure 1-1 Solar Cell

[www.howstuffworks.com]

Using this information obtained about the laptop and solar cell, it is now possible to proceed with the project. The XO Laptop needs to be powered using solar power, but the panel used to power the laptop cannot cost more than $80, nor can it be fragile or bulky.

2.0 Problem Formulation

The $100 XO Laptop is a low-cost subnotebook computer with a plan to be given to children developing countries around the globe. This will provide them with access to knowledge and information which was previously unavailable to them, and also give them opportunities to learn and benefit through the internet. The XO laptop is perfect for the children in third world countries because it offers sophisticated technology for little cost. The XO brings a whole new level of technology to the developing world with its energy efficient and durable design able to withstand some of the most extreme weather conditions.

There is only one flaw in the design of the XO laptop, its energy source. In the third world, children have little to no access to electricity. The task is to design solar powered system to charge and run this laptop. The system must be reliable enough so the children do not have to concern themselves about how long they can use the computer for. Many of these clients in third world countries do not have access to any electricity and will also be using this laptop as a main source of light in the night. Therefore we need to have the laptop solar powered system so that it can be used in remote locations without direct access to power and that will be able to hold a charge for a fair amount of time.

The solar powered system for the laptop must not only be reliable but also durable, because if something goes wrong it could be expensive to fix. Since the laptop will be used by children in the developing world, the solar powered system must be able to survive after taking a fall and even some harsh weather like rain and extreme heat.

These aspects must be taken into consideration while designing a solution for the solar powered XO laptop. The XO laptop is an inexpensive piece of technology so that the world can benefit from them. In designing the solar powered system, the cost will be a large task to overcome. The cost of the solar powered system must be cheap enough so that the entire machine will not become so expensive that the project is undoable.

3.0 Design Plan

3.1 Design Specifications Criteria

To determine the best possible design solution, the designs will be analysed and tested in the four following areas; durability, power input, cost, and general compatibility and practicality.

Table 3-1

Criteria	Specifics
Durability	• Able to withstand everyday abuse such as dropping or • Cords must be strong enough to withstand tugging and stretching • Watertight • Require little or no maintenance of mechanical or electrical components
Power Input/Output	• Run the laptop while charging it in full sunlight • Output between 10 and 15W at 12V • Charge the laptop in under 4 hours in full sunlight • Not overheat or overcharge of the laptop
Cost	• Use cheap materials whenever possible without sacrificing quality • Keep components simple to keep manufacturing cost low
General Compatibility and Practicality	• Plug must fit into laptop smoothly • Must be easy to set up and use

3.1.1 Laptop Specifications

- DC power: 6mm (1.65mm center pin) connector; 11 to 18 V input usable, –32 to 40 V input tolerated; power draw limited to 15 W;
- Pack type: 2 or 4 cells LiFePO4; or 5 cells NiMH, approximately 6V series configuration;
- Capacity: 22.8 Watt-hours (LiFePO4); 16.5 Watt-hours (NiMH);
- Fully-enclosed "hard" case; user removable;
- Electronics integrated with pack provide:
- Identification;
- Battery charge and capacity information;
- Thermal and over-current sensors along with cut-off switch to protect battery;
- Minimum 2,000 charge/discharge cycles (to 50% capacity of new);
- Power management will be critical.

[http://laptop.org/en/laptop/hardware/specs.shtml.]

3.2 Possible Design Solutions

All three design solutions included here are planned to produce similar wattage, voltage and current. The differences are in the aesthetics, practicality, the method of connection to the laptop, and whether they are physically touching the laptop or not. The checklists on the right hand side of Tables 3-2, 3-3 and 3-4, are ranked by a '**√**' for positive attribute, 'X' for a negative attribute, and a '**-**'for an attribute that is neutral towards the design criteria.

3.2.1 Standalone Unit A

Standalone Unit A, as seen in Figure 2, consists of a two folding solar panels mounted on a tripod. This design is intended to be the most practical unit, but the drawbacks associated with the construction and manufacturing costs may outweigh the benefits.

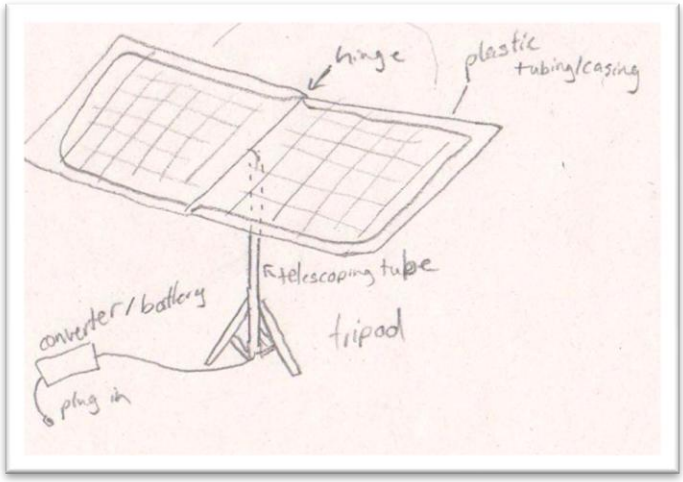

Figure 2

Table 3-2

Criteria	Specifics	Checklist
Durability	• Able to withstand everyday abuse such as dropping or • Cords must be strong enough to withstand tugging and stretching • Watertight • Require little or no maintenance of mechanical or electrical components	√ - - X
Power Input/Output	• Run the laptop while charging it in full sunlight • Output between 10 and 15W at 12V • Charge the laptop in under 4 hours in full sunlight • Not overheat or overcharge of the laptop	√ √ √ √
Cost	• Use cheap materials whenever possible without sacrificing quality • Keep components simple to keep manufacturing cost low	X X
General Compatibility and Practicality	• Plug must fit into laptop smoothly • Must be easy to set up and use	√ -

3.2.2 Standalone Unit B

Standalone Unit B, as seen in Figure 3, consists of one or two larger solar panels wired in sequence, with two legs to prop it up. This early design includes a folding hinge in the middle, telescoping legs, and a clip that would allow for attachment to the laptop.

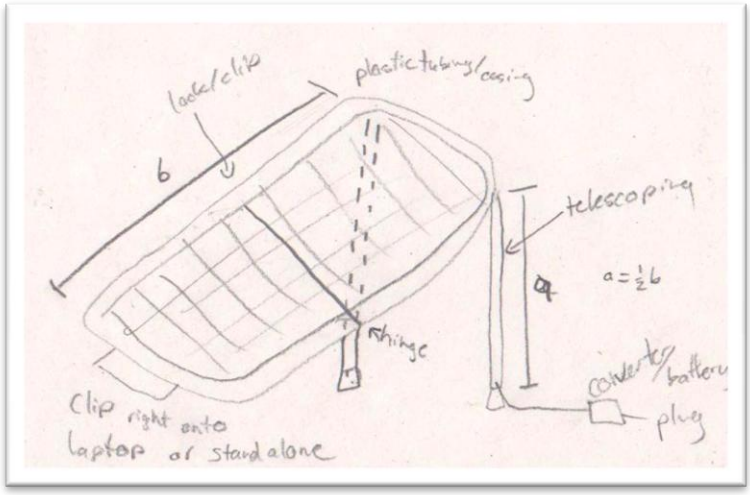

Figure 3

Table 3-3

Criteria	Specifics	Checklist
Durability	• Able to withstand everyday abuse such as dropping or	√
	• Cords must be strong enough to withstand tugging and stretching	-
	• Watertight	√
	• Require little or no maintenance of mechanical or electrical components	√
Power Input/Output	• Run the laptop while charging it in full sunlight	√
	• Output between 10 and 15W at 12V	√
	• Charge the laptop in under 4 hours in full sunlight	√
	• Not overheat or overcharge of the laptop	√
Cost	• Use cheap materials whenever possible without sacrificing quality	-
	• Keep components simple to keep manufacturing cost low	-
General Compatibility and Practicality	• Plug must fit into laptop smoothly	√
	• Must be easy to set up and use	√

3.2.3 Design C

The connected unit, as seen in Figure, 4 allows for the solar cells to be directly clipped onto the laptop. This is designed for convenience, but the user would have to be in direct sunlight to work. The drawback of this design is that the solar cell itself would have to be either incredibly efficient, or much larger than the laptop itself and extremely light. This makes the design unfeasible because the cost would be far too high.

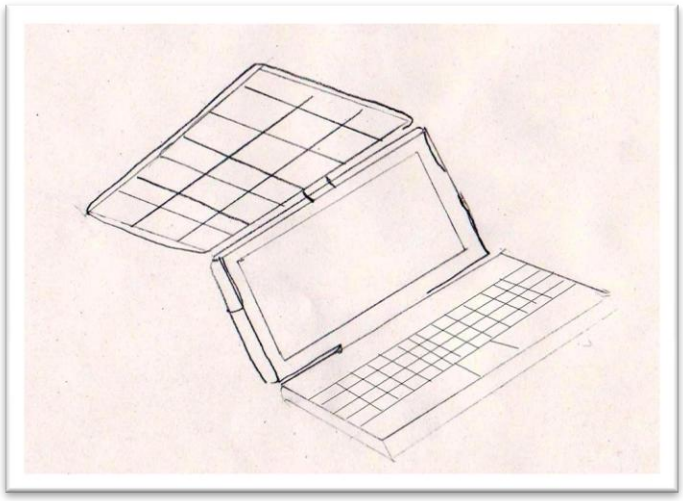

Figure 4

Table 3- 4

Criteria	Specifics	Checklist
Durability	• Able to withstand everyday abuse such as dropping or	-
	• Cords must be strong enough to withstand tugging and stretching	-
	• Watertight	√
	• Require little or no maintenance of mechanical or electrical components	-
Power Input/Output	• Run the laptop while charging it in full sunlight	-
	• Output between 10 and 15W at 12V	-
	• Charge the laptop in under 4 hours in full sunlight	√
	• Not overheat or overcharge of the laptop	√
Cost	• Use cheap materials whenever possible without sacrificing quality	-
	• Keep components simple to keep manufacturing cost low	-
General	• Plug must fit into laptop smoothly	√

Compatibility and Practicality	• Must be easy to set up and use	√

3.3 Chosen Design

After analysing each solution, the best design for the laptop is Standalone Unit B. A simplified version of the design, as shown in Figure 4, will improve on the drawbacks, reducing costs and manufacturing prices, without sacrificing too much in terms of practicality. The hinge in the middle has been removed, as well as the telescoping legs, opting for simpler hinged fold-up legs. Overall, this design could work because it is simple enough to keep costs low, while maintaining its durable exterior and practicality.

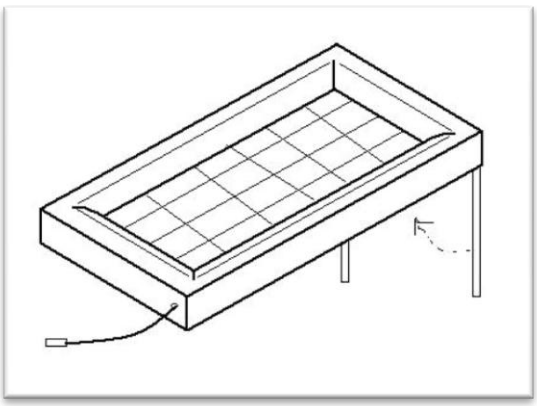

Figure 5

3.3.1 Budget

Table 3-5 Budget Predictions

Materials	Predicted Cost
Solar Cell(s)	$30.00-$50.00
Casing	$15.00-$20.00
Legs	$5.00
Wiring, electronics	$10.00
	$60.00-$85.00

3.3.2 Timeline

The timetable (Figure 6) will keep track of whether the project is on time or not. It allows for possible setbacks like delivery times.

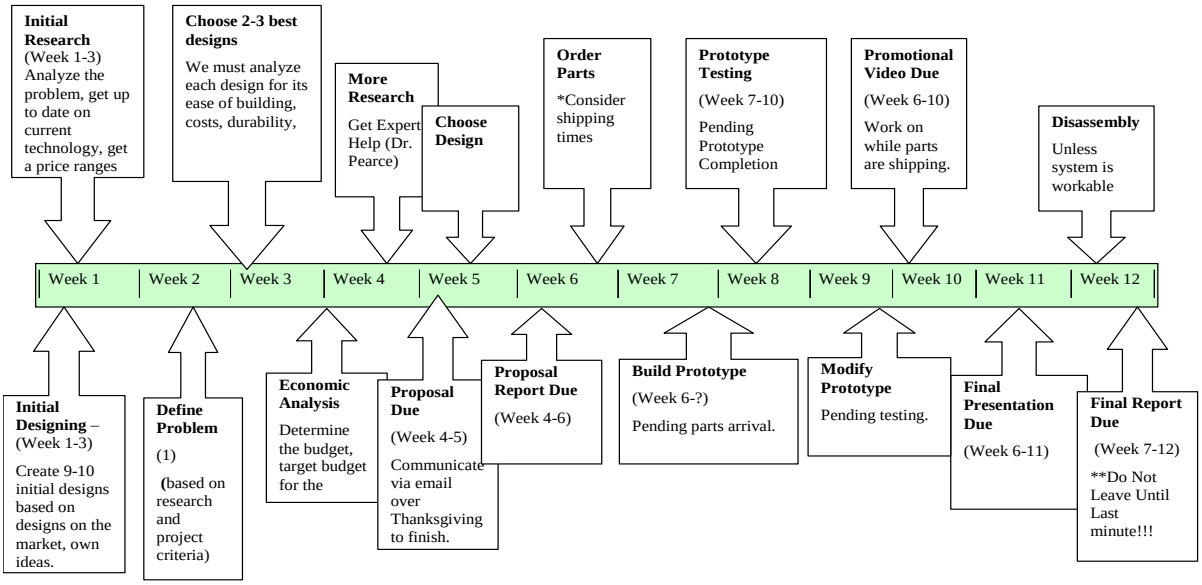

Figure 6

3.3.4 Plan for Evaluation

To evaluate this design, the following tests will be performed, as seen in the sample test Table 3-6 below.

Table 3-6

Test	Checklist
Charge the laptop in under 4 Hours? While the laptop runs?	
Can the wires be tugged on without coming apart?	
Will the unit survive a drop? Multiple drops?	
Is the unit watertight?	
Does the unit not overheat the laptop?	
Is the unit easy to set up and use? No mechanical issues?	
Does the plug fit into the laptop smoothly? Does it come out smoothly?	

4.0 Economic Analysis

In designing the solar powered system for the XO laptop cost must be taken into consideration. The point of the XO laptop is to put advanced forms of technology into children's hands that normally do not get the opportunity because of financial troubles. The less expensive the solar powered system is the more feasible solution it will be.

The construction of the prototype should come in under eighty dollars. While being inexpensive the solution also has to be functional and reliable. Research has shown that these previous attempts were unsuccessful with more resources and expertise at the disposal of the designers.

Solar cells have dropped dramatically in price over recent years. The average solar panel will cost about five dollars a watt and with the XO laptop running at 15 watts the price will escalate quite quickly. After extensive research, it was concluded that may be feasible to construct a solar powered system for less than eighty dollars however to do so on the prototype scale will be a different challenge. With no real potential income with this project, cost will be a large factor in all major decisions.

5.0 Conclusions

Extensive research has been conducted about the solar panel laptop, and we have the knowledge to determine an appropriate solar panel that will give the needed amount of power while still costing under the budget. We chose the design because it fits the needs of the clients the best. The design is durable, functional, and practical. When the solar panels come in, it will be necessary to determine an effective way to connect it to the laptop in order to make use of the solar power. This is where we will need to research more about the circuitry of the laptop and the solar panel.

6.0 References

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7.0 Individual Contributions

7.1 Qaseem Jiwani

In this project I have helped in researching about the background information about the solar panel. I have helped make sure that we have met our deadlines and that we have not fallen behind schedule. I also contributed to creating some of the possible designs of the solar panel. In the presentation I explained about what the XO Laptop was and what the goals of the OLPC organization were. I wrote the executive summary, as well as the introduction and the conclusion of this proposal report.

7.2 Brendan Graham

In this project, I have come up with many design solutions for the solar panel, as well as determining the pro's and con's of each one. I have tried to manage meetings to make them more time-effective, and collected information from the group to submit to our project manager. In the presentation, I discussed the method which we took to determine our design, as well as the pros and cons of each possible solution. In this report, I wrote section 3, Design Plan, and created images for each possible solution. Furthermore, I formatted the document to

the specifications outlined in the course manual, including creating the table of contents and table of figures and tables. I also proofread the entire document, and combined group member's sections and finalised the document.

7.3 Cody Boutilier

In this Project, I have been helping in the booking times of where and when we can meet. I have played a large role in researching locations for purchasing our supplies needed in order to construct our prototype. With the Proposal presentation I was in charge of outlining the Problem and our task as well as the cost analysis. As for the Proposal report, I was in charge of both the problem formulation and the Economic analysis. I also helped in formatting and editing the report.