GNG1103

**Deliverable E: Project Schedule and Cost**

**3D Printer Monitoring System**

Submitted by

**GNG 1103, Section A3, Group 1**

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# Introduction

The objective of this deliverable is to develop a project plan and a schedule to ensure that our team is on track to complete all three project prototypes on time. This plan also outlines the estimated cost and components that will be required for our prototypes and final design.

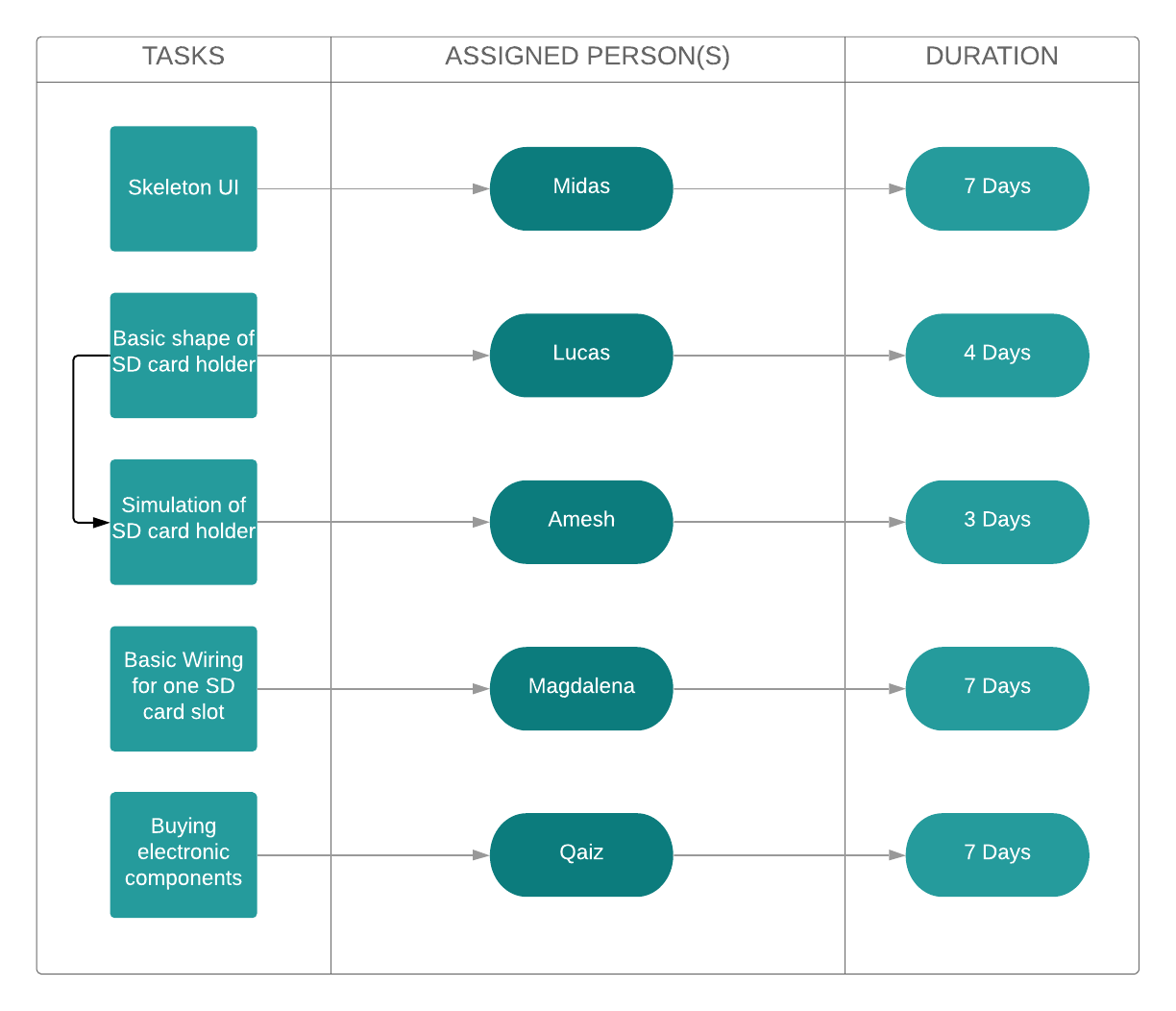
Three prototypes are due from now until the end of the semester. The first one is a simple proof of concept and will be built using cheap materials found around the Makerspace or at home. It will include a simple analysis of critical systems and some of the components, such as a basic, non-functional UI and a test card slot to check if it is possible to check electronically if an SD card is in place or not. The second prototype will be a low-cost/medium fidelity design to analyze and test all the critical subsystems of our design to ensure that we have a working design. An analytical and numerical analysis of all the subsystems will be included. This will lead us into the third prototype, which is our final working design.

In order to come up with this project plan and make it as detailed as possible, we will include a list of all the tasks that need to be completed for each prototype, as well as the duration and team member responsible for each of those tasks. This information will be compiled in a Gantt chart to make it easier to follow and to highlight our critical path of tasks that need to be completed on time to keep the project on track. Also, project planning includes creating a project risks and contingency plan. Issues will arise during prototyping with our materials, subsystems or simply not being able to work on this project as much as we would like due workload from other courses. Creating a plan that highlights the potential risks we will be facing during the course of the semester as well as well as a contingency plan to solve those issues as they arise will be very important to ensure that we do not get sidetracked at any point during prototyping. Finally, the last step will be to break down all the required components for the various prototyping steps and coming up with an estimated cost for all of them to ensure that we stay within the 100$ budget allocated for the purposes of this project.

# Project Plan

## 1). Tasks to Be Completed

### *Prototype 1*

The initial prototype focuses on a low fidelity/low cost model to show to the clients and to observe as a team to check general functionality. This is done to help validate the initial concept and reduce the uncertainty of future models. Essentially, it will provide the bare basic information to see if the current solution holds value as a product and avoid any critical flaws. It will include a simple physical model with basic materials and a simulated model in solidworks. The physical model will be used to help communicate the simulated model which will naturally be more accurate. Then comparaisons can be made between simulation and reality in the basic sense as both models lack comprehensibility. A focused prototype will be made as well in regards to a basic, non-functional Dashboard UI. This will help model the basic idea of the UI. Another low fidelity model will include the basic wiring for one SD card slot to check if it is possible to tell electronically if SD card is in place or not.

*Task List for Prototype 1*

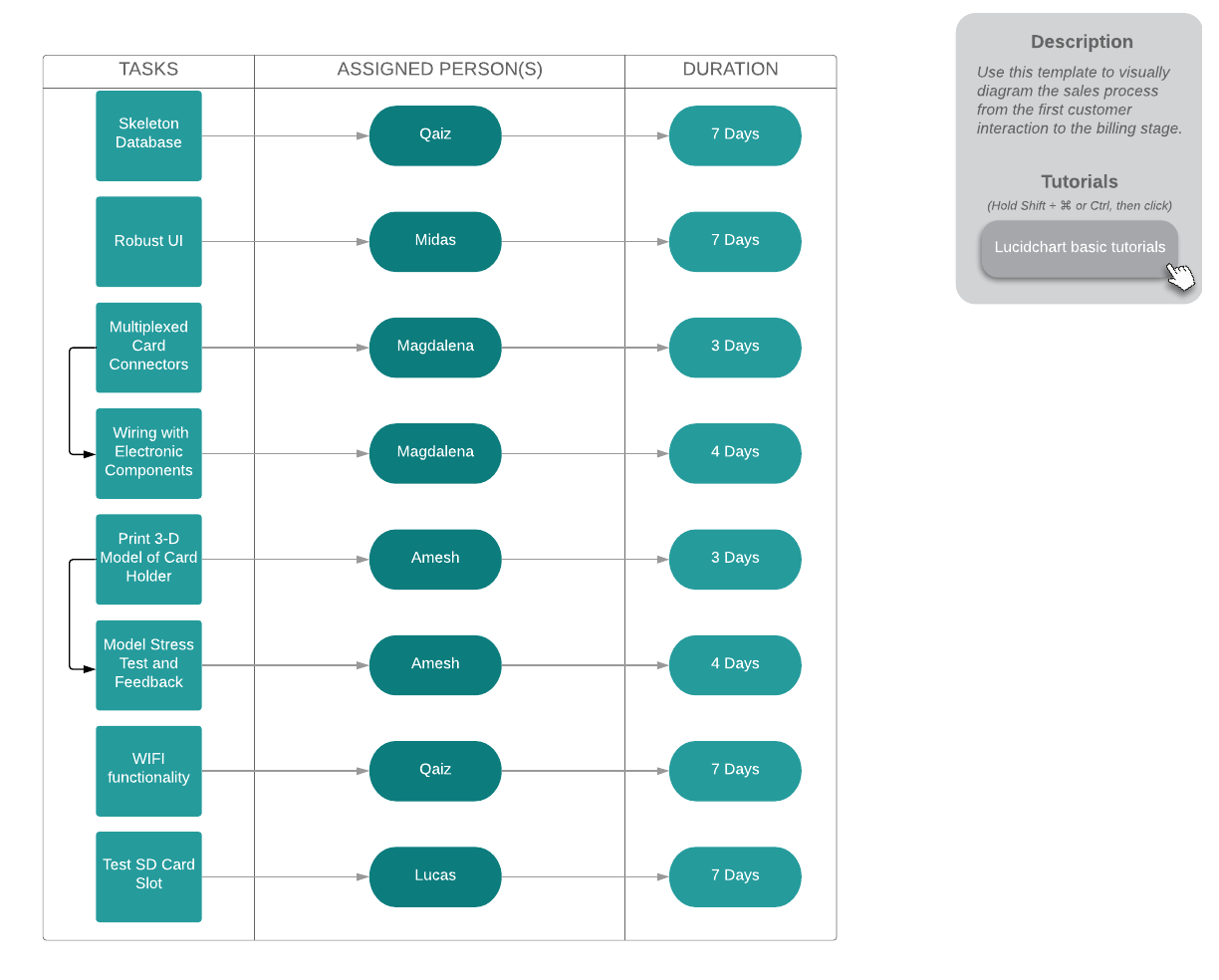
## *Buying List (Deadline: October 22nd) - Qaiz*

1. Raspberry Pi / Arduino Uno with Wifi Shield
2. Breadboard
3. Quick wires
4. Card slot

### Prototype 2

The second prototype focuses on a medium fidelity/low cost model to show to the clients and to observe as a team to check the functionality of certain aspects. We will also use the initial prototype as a reference to help indicate feasibility of prototype 2 through careful analysis of the results and feedback given to this group from prototype 1. This is done to help validate the initial concept and reduce the uncertainty of future models. Essentially, it will provide some information to see if the current solution holds value as a product. Furthermore, more benchmarking will be done at this step to compare different sensors and different physical designs.

It will include a more robust and functional UI to gauge user accessibility and usability of the product with more feedback from the client as well as other potential CEED users within the group and outside of it. The beginning of a more focused testing on wiring with multiplexers, LEDs, switches, sensors (*ie:* all forms of electronic testing) to better understand how they work and analyse the best combination for the final product. Another physical model, alongside its respective simulated model, will be created and updated based on the feedback given in prototype 1. The physical model will be 3D-printed and potentially integrated with some wiring for feedback from clients and to better gauge the opinions in regards to the final product. WIFI functionality will also be tested in this prototype to integrate the microchip with Dashboard to test success. The SD card holder component will also be attached onto the physical model for use and testing.

*Task List for Prototype 2*[**](https://www.lucidchart.com/documents/edit/108af62c-08ea-4219-89f7-84f461057177/0?callback=close&name=docs&callback_type=back&v=175&s=612)

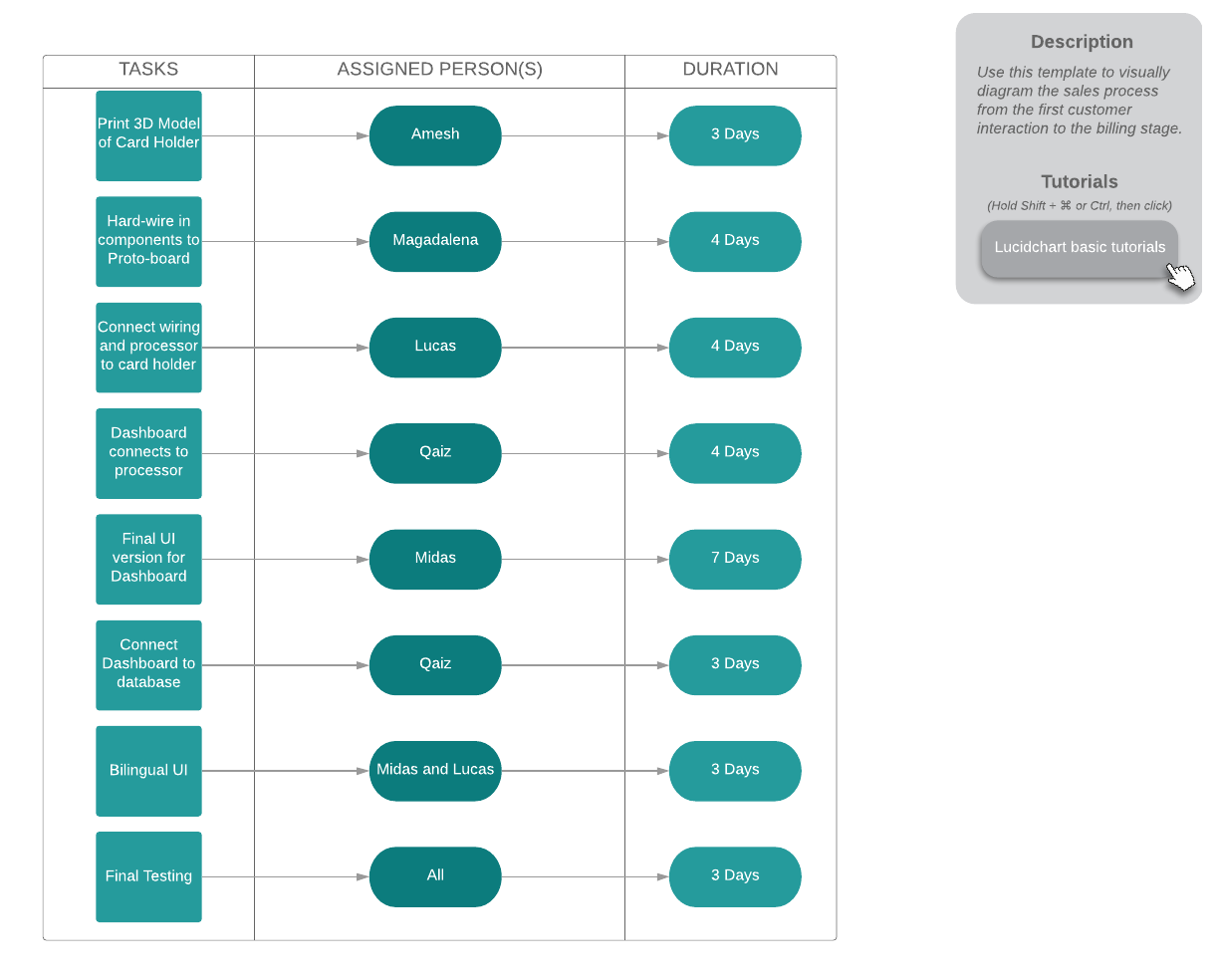
## *Buying List (Deadline: November 3rd) - Qaiz and Magdalena*

1. Wires
2. Multiplexer
3. LEDs
4. Switch
5. Sensor

### Prototype 3

The final prototype focuses on a high fidelity/medium cost model to show to the clients for feedback and to observe as a team to check the functionality of all finished aspects. We will also use the second prototype as a reference to help indicate feasibility of prototype 3 through careful analysis of the results and feedback given to this group from prototype 1 and 2. This is done to help validate the current solution and reduce the uncertainty of future models. This will also be used to indicate current project progress and present the final product in the most comprehensive detail thus far. It will also be used to help verify if the product is ready for launch.

It will include an updated 3D printed model alongside its simulated part. Both will be on display and be used to compare how the final physical part turned out after being printed vs. the simulated part. The final part will also be used to help users understand its functionality and receive some first-hand understanding and experience. Components will be hardwired into the protoboard and all wiring will be soldered. The processor will also be connected wirelessly to the computer/Dashboard. The final Dashboard UI will be almost/completely functional and will be accessible and on display for users to test and use. It will have display functionality, sorting functionality and other types of information available. Lastly, the Dashboard interface will be available in both French and English. Dashboard may also be connected to a dummy database for testing purposes.

*Task List for Prototype 3*[**](https://www.lucidchart.com/documents/edit/4907d579-52e4-4fb2-80c0-67d084c831f0/0?callback=close&name=docs&callback_type=back&v=585&s=612)

## *Buying List (Deadline: November 10th) - Midas*

1. Protoboard
2. (*Potentially)* Doubling up on all electronics to indicate interlocking features

## 2). Gantt Diagram

## 

## 

## 3). Project Risks and Contingency Plans

When completing a project like this one with many moving parts and deadlines, we have to take into account the risks associated with the project and create a contingency plan to deal with them if they arise.

Being full time students, we all have busy schedules with classes and work. Midterms and due dates for other courses could prevent us from completing our tasks for this course on time. One solution to that problem would be to abandon unnecessary features (ex: table, database functionality, language switching, WIFI). This solution could also solve coding problems that would arise if we have too many parts to our code that we cannot integrate into the project. Dropping non-essential sections of the code would allow us to focus on making the prototype work and be ready for Design Day, which is most important.

Our project could also be delayed by various technical problems such as the Arduino not being able to handle our code, the multiplexer plan not working or our card sensing method not functioning reliably. If those problems arise, we will come up with alternative plans to make our project work. For example, we could replace our Arduino with a Raspberry Pi to handle our code. For multiplexer issues, switching to pre-made expanding data pins on the processor is also another option. Finally, if our card sensor design does not work as well as we expect, we will switch to a physical switch method as a last resort if we fail to come up with another sensor design that works. That way, we will have a final working prototype by Design Day.

Our project could also be compromised by software issues. Since we will be working with databases linked to the 3D printers such as printing time remaining, color of material used, etc. we have to ensure that Dashboard can accommodate those databases for the purposes of our project. If it does not, we will have to cut out some of those databases and keep the ones that are working, which means providing less information about the printers to users of our design.

Finally, since we will be ordering parts for our prototypes online, there is a chance that our parts will not be coming on time. If that happens, we will get our parts from other component stores, or Amazon, even if it is less convenient to do so.

# Estimated Cost

Our design incorporates some complex elements, however our physical product will consist of less than 10 kinds of components. Our prototyping plan allows us to use our materials efficiently as every electronic component that we buy can theoretically be tested with a breadboard and then reused in the final product. As of the time of submitting this report, we are unsure if we will be able to have a final prototype that consists of one or two interlocking parts, so we have ensured that we have enough parts for two if we have the time to build two. We understand that parts can arrive broken and can be damaged in testing, so we have added in a redundant number of components where it is reasonable to do so.

## Bill of Materials

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **ID** | **Description** | **Vendor** | **Part Number** | **Qty** | **Cost** |
| 1 | 1.74m Ultimaker PLA Filament[[1]](#footnote-0) | uOttawa Maker Store | -- | 1 | $1.40 |
| 2 | Jumper Wires | uOttawa Maker Store | -- | 30 | $3.00 |
| 3 | Arduino UNO WIFI Rev2 | Mouser Electronics | 782-ABX00021 | 1 | $63.76 |
| 4 | Panel Mount 3-pin LEDs - Red/Green | Mouser Electronics | 749-PM5R3-BC | 10 | $6.96 |
| 5 | Parallel-Load 8-Bit Shift Registers | Mouser Electronics | 595-SN74HC165N | 10 | $5.64 |
| 6 | 400 Tie Point Solder PC Breadboard | Mouser Electronics | 854-SB400 | 1 | $7.09 |
| 7 | SD Card Push-Push Connectors | Mouser Electronics | 945-FPS009-3202-BL | 10 | $18.00 |
| 8 | USB Cable | Mouser Electronics | 713-321010008 | 1 | $2.77 |

*Note 1: These prices are all in CAD on their respective websites and are calculated before Ontario HST rates of 13%.*

*Note 2: Shipping is negligible in our calculations because we are able to pick up items from the Maker Store in person and free global express shipping is included from Mouser Electronics when the total sum in CAD exceeds $100.*

Total sum at the uOttawa Maker Store with tax and shipping: CAD $ 4.97

Total sum at Mouser Electronics with tax and shipping: CAD $ 117.77

**Total Sum of Material Costs: CAD $ 122.74**

## Discussion

The biggest cost associated with this project will be the processor. We have chosen to go with Arduino over Raspberry Pi because it is better documented and our group has more collective experience with Arduino over Raspberry Pi. We chose the Arduino Uno Wifi Rev2 because it comes with wireless capability without needing to install extra shields and risk human error in soldering together parts.

The relative cost of the electronic components is small because these parts are simple and mass-produced. There is an overwhelming amount of choice on the market for these items, however we picked our components deliberately. This model of SD connector was chosen because we wanted an intuitive push-push (push to insert, push again to remove) connector like the ones that are already in the Ultimakers. This model of LED was chosen because it effectively gives us three colour options (red, green, none) but only requires 2 data pins to function (the 3rd pin being ground, which does not require a data pin). This 8-bit register was chosen over a conventional 8-to-1 MUX because it allows for data input and output, which we will need to both read information from our SD card and send a signal to our LEDs [1]. There are also similar open-source projects online that give some groundwork on how to work with incorporating these components into a project using Arduino [2] [3]. This solder-on breadboard was chosen for having the most convenient pin placement over similar products on the Mouser Electronics website. The secondary criteria for all of our electronic components was price.

We looked at many different electronic suppliers (ex: Amazon, Digikey, Active Tech, Newark, SparkFun Electronics, and AliExpress) and we chose to go with Mouser Electronics. This is because it has all of the parts we need in stock and it ships quickly within Canada.

We strategically went over budget because we are guaranteed free express shipping on orders over $100 CAD compared to their typical express shipping rate of approximately $30. In this way, we can get $122 worth of materials for $122, and not $70 worth of materials for $100.

We have chosen to use some materials supplied by the uOttawa Maker Store, namely jumper cables for prototyping and the PLA filament that we will use to print the body of our card holder.

# Conclusion and Next Steps

In this report, we came up with a project plan that will ensure that our team stays on track to complete all three project prototypes from now until the end of the semester on time while staying organized and diligent with our work.

We broke down the tasks and the timeline of completion for each prototyping phase. Our first prototype will be low fidelity and its purpose will be to get an idea of what our design and UI will look like once they are completed, as well as detect any irregularities with it as soon as possible. The second prototype will be medium fidelity/low cost, and will serve to demonstrate the functionality of our subsystems and UI. Finally, our third and final prototype will be high fidelity/medium cost and will be presented to the client for feedback and grading. During those project prototype phases, we will have followed our risk management and contingency plans to deal with any issues that came up along the way. Also, we will have followed our cost estimate analysis and budgeting for all necessary components in order to ensure that we stay under the budget allocated for this course.

Having a robust and reliable project plan is key if we want to complete those steps as described without being sidetracked and running late on due dates for deliverables and prototypes. Once this plan is completed, it serves as a tool for us to use to complete our projects tasks on time.

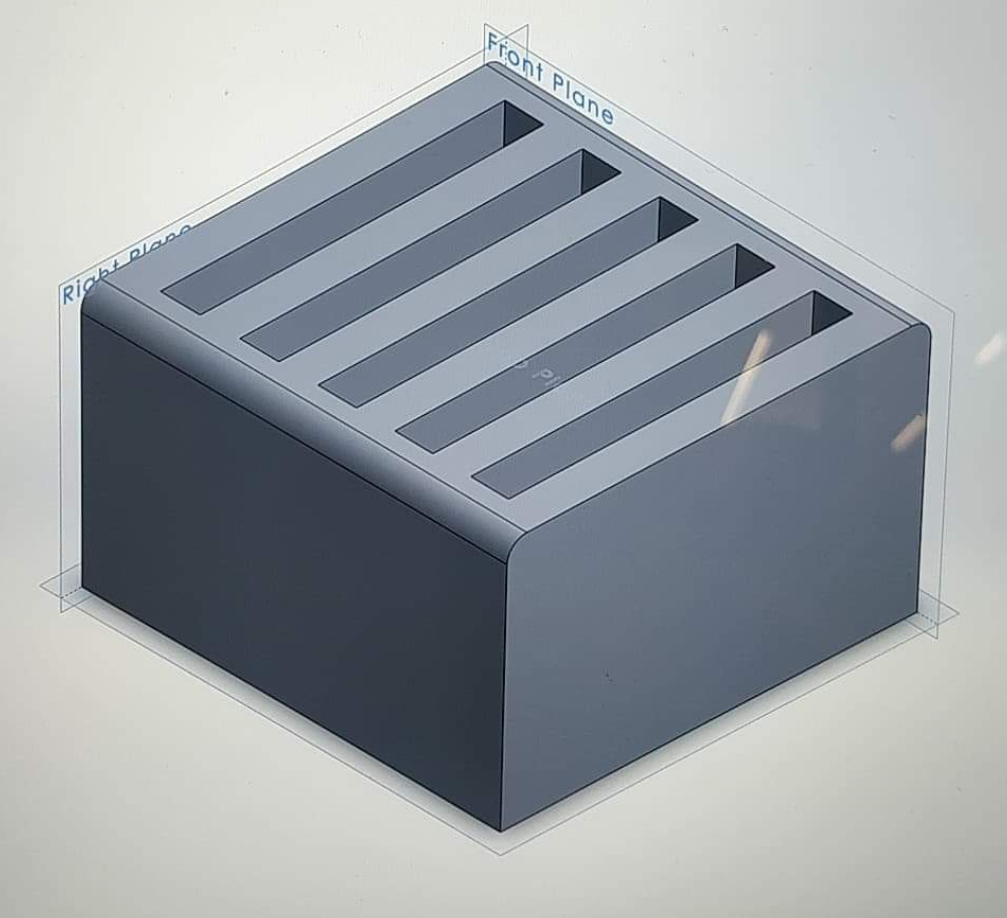
# References

[1] - Amanda Ghassaei. “Multiplexing With Arduino and the 74HC595.” Instructables.com. <https://www.instructables.com/id/Multiplexing-with-Arduino-and-the-74HC595/> (Accessed Oct. 16, 2019)

[2] - Open Electronics Project. “74HC165 Shift Register and your Arduino UNO.” Blogspot.com. [https://openelectronicsproject.blogspot.com/2015/10/ 74hc165-shift-register-and-your-arduino.html](https://openelectronicsproject.blogspot.com/2015/10/74hc165-shift-register-and-your-arduino.html) (Accessed Oct. 16, 2019)

[3] - Sean Hodgins. “MegaMUX - 32 Channel Multiplexer Tutorial”. Instructables.com. <https://www.instructables.com/id/MegaMUX-32-Channel-Multiplexer-Tutorial/> (Accessed Oct. 16, 2019)

# Appendix 1: Calculation of PLA Cost



To calculate the cost of our SD card holder, we can create a rough model of what our final holder will look like, shown above. Solidworks calculates that this shape has a total volume of 11.1cm3.

Next we can look at the spool of PLA, which has a diameter of 2.85mm, a length of 90m, and a price after taxes of $62.09[[2]](#footnote-1).

To determine the cost of our model, we can use the formula:

Factoring in a margin of about 15%:

This gives us our projected cost of $1.40 for the PLA for our 3D printed part.

1. See Appendix 1 for the calculation we used to determine this cost. [↑](#footnote-ref-0)
2. According to the Canadian 3D printing supply shop <https://shop3d.ca/products/ultimaker-pla>. [↑](#footnote-ref-1)