May 14-06

# Project Plan v2

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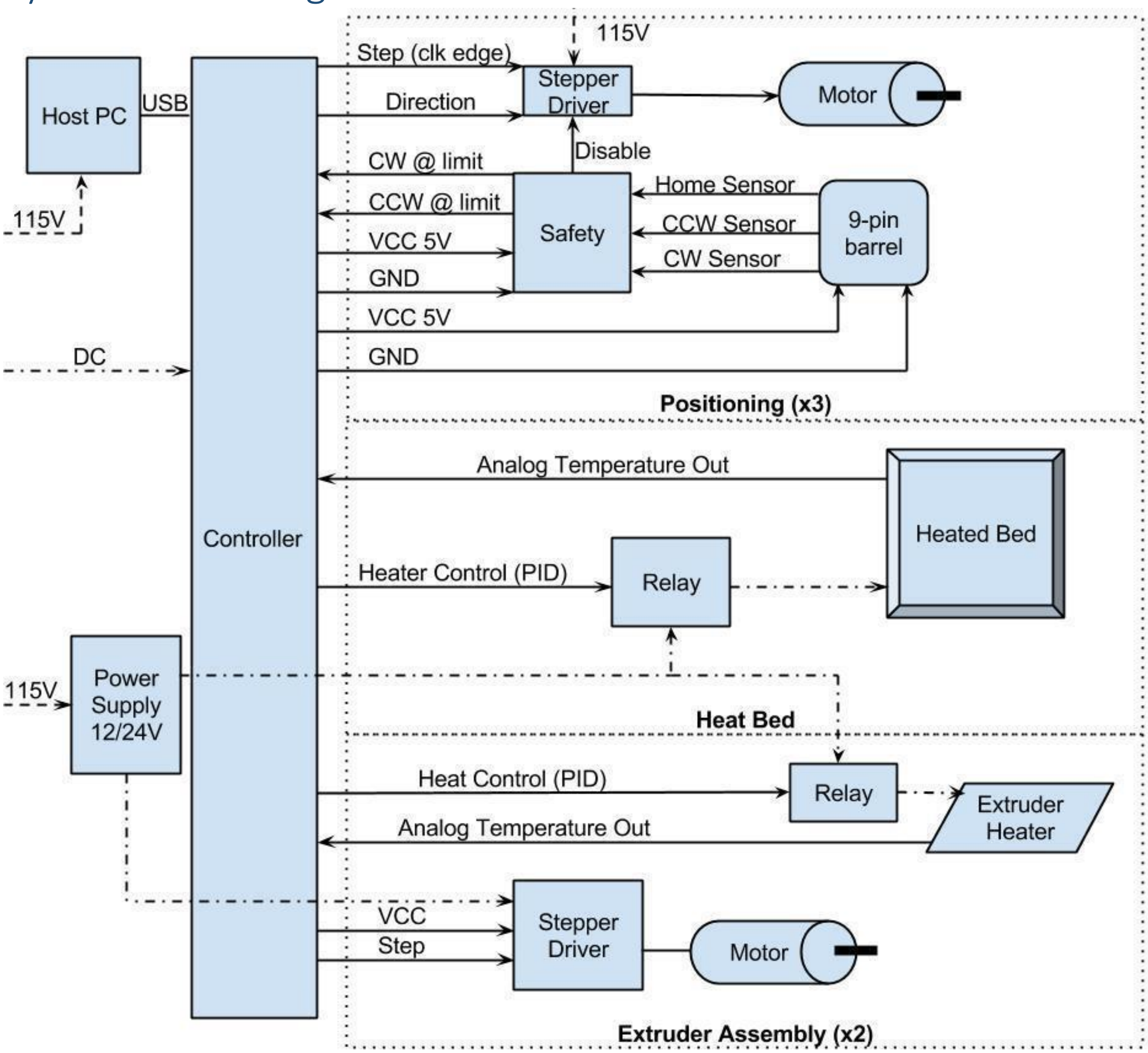
# Problem Statement

Our client, Dr. Tom Daniels, wants to repurpose an old 3-axis positioning system into a 3D printer. Ideally it will have a heated bed and dual extrusion capabilities. While building a DIY 3D printer is not a challenging task, molding this system into a 3D printer is. This is due to the large scale of the printer – at nearly 20in x 20in the print bed is massive. Most printers on the market today only support an 8in x 8in printing area. In addition to adapting current solutions, we must add all necessary safety equipment to prevent harm to the equipment as well as people.

# System Block Diagram



## Functional Requirements

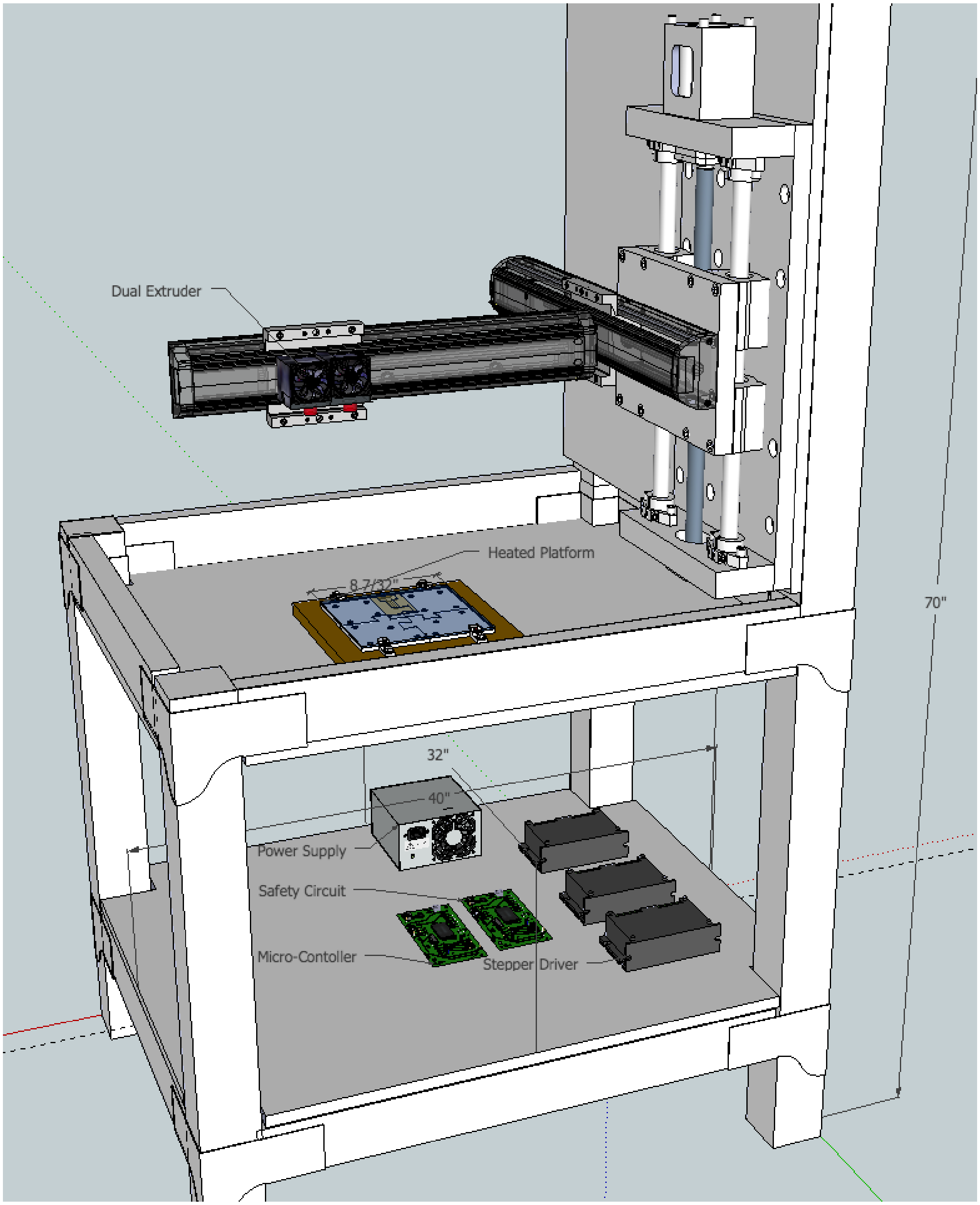
The functional requirements of this project are to create the hardware for a 3D printer that is able to be programmed from the software team to work as a fully functional 3D printer. The printer must be able to move in 3 dimensional space controlled by the arduino as well as control the molten plastic extrusion. The printer must have an extruder capable of handling 1.75 mm plastic filament. We must have a power supply capable of supplying the power needed by the entire printer, including the stepper motors, heated extruder, and heated bed. A host PC will be needed to program and communicate with the microcontroller. The printer must also include working “safety circuits”. These will ensure the 3 axis system will not try to move passed its bounds, potentially causing damage to the hardware. This system will need to stop the printer from moving as soon as one of the six limit sensors are tripped.

## Non-Functional Requirements

- Sturdy table to minimize vibration from moving axes
- Cable management
- Casters om the new bench
- Permanent solutions for the current breadboard safety circuits

## Deliverables

During the final presentation of our 3D printer, the hardware team will deliver a working dual extruder, a heated platform to print parts on, safety circuitry, and a power distribution system. Our team is in the process of completing a large sturdy workbench to house the entire system into one package. The figure on the next page shows the top shelf which will be dedicated for printing and the bottom shelf which will house all of the electrical components. The top platform of the bench will be used to support the 3 axis positioner as well as our heated printing platform. On the bottom shelf of the bench, we will organize all of the electrical components including power supply, safety circuits, and stepper motor drivers. The largest axis, the z axis will move the x and y axis vertically while the unit is printing. At first, our team was concerned that the z axis would not be able to lift the other 2, but testing has confirmed that the stepper motors are powerful enough to handle the load. The heated platform will be on the bottom.



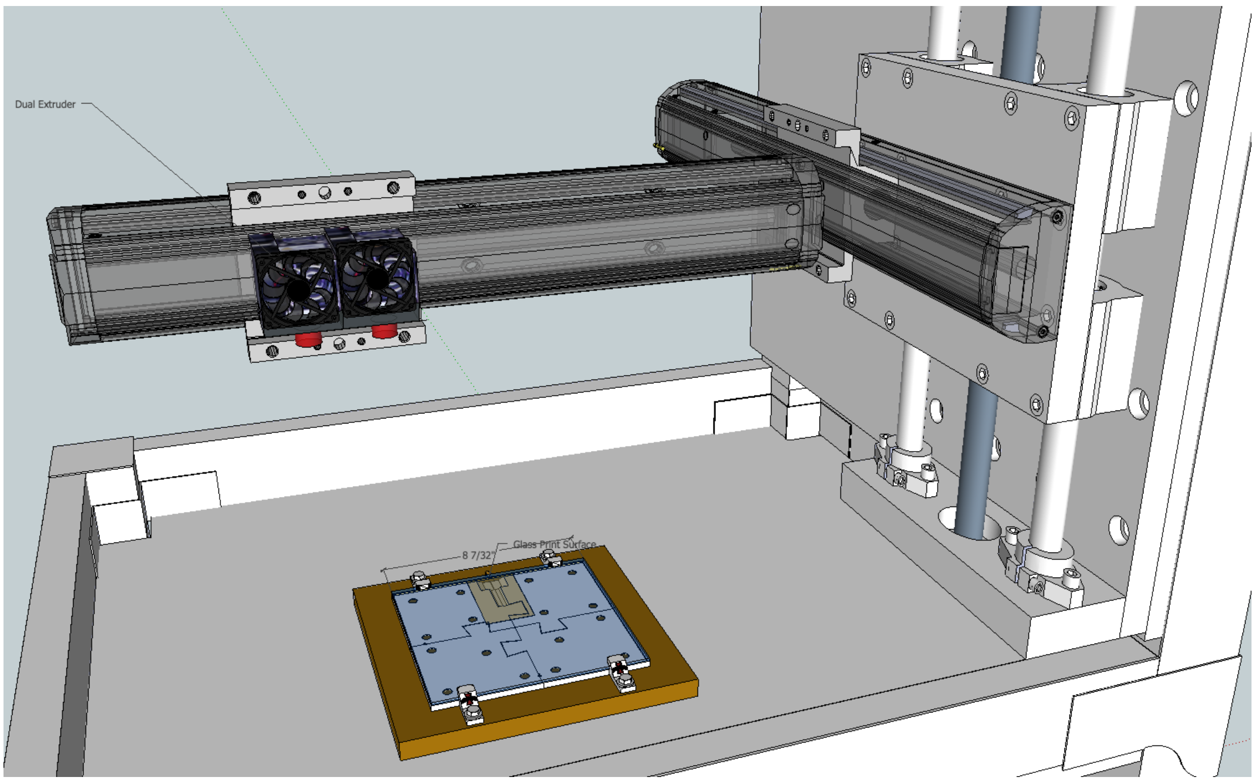

**CAD OF ALL DELIVERABLES COMPLETE**

**Dual Extruder**:

Printing with a dual extruder opens up many exciting possibilities with 3D printing. This feature allows for multi colored prints as well as multi material prints. The dual extruder will be a component that we will purchase and assemble.

**Heated Platform:**

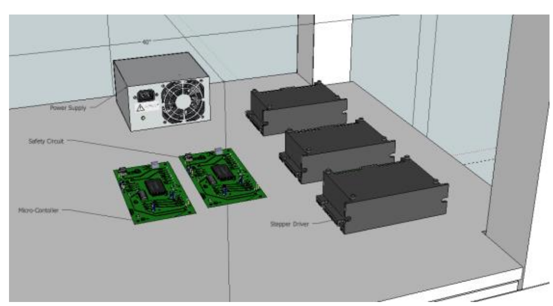
The print platform will include a heating element that will be controlled by the micro controller during printing. The platform that we will use for printing will be heat treated glass. A silicone heating element will be placed under the glass and be able to heat up to about 120 degrees C. Heated platforms prevent the plastic parts from warping during printing. This element is not found on most inexpensive 3D printers but our team and advisor felt that a heated platform would yield the best results. The platform will also consist of 4 leveling screws in every corner. These screws will be adjustable and allow for easy leveling of the print platform.




**HEATED PLATFORM AND DUAL EXTRUDER**

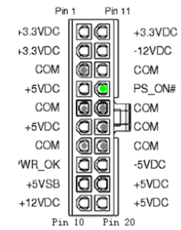
**Safety Circuitry:**

Each axis has a sensor on either end of the axis that when triggered, instantly bring the stepper motors to a stop. This sensors are built into the positioner and prevent the machine from trying to move the axis farther than their range of motion. This circuit is connected directly to the stepper motor drivers to ensure the steppers stop as soon as the sensor is tripped, but will also feed back into our microcontroller so the software and program can see which axis has been trip and make the necessary adjustments.



**ATX power supply:**

When used as a traditional computer power supply, the computer motherboard provides the power supply with an enable signal. We will emulate this enable signal by jumping pin 13 to ground. This will enable the power supply and allow us to utilize various voltages at an economical cost. Shown below is the standard 20 pin motherboard to power supply connector.




# Work Plan

## Work Breakdown Structure

This project requires the collaboration between a hardware team and a software team. Decisions made by our team will involve the physical moving parts, including the extruder, positioner, heated platform, safety circuit and power distribution. Our team has built a bench and have positioned the xyz axis system in a way to maximize printing area while minimizing overall space. We have tested all stepper motors with a test mode on the stepper drivers to ensure that the load on the vertical z axis will not pose a problem down the road.

Hardware decisions have been made by our team at this point. We have chosen to purchase a dual head extruder, a silicone heating element for the print bed, and a suitable power supply. We have to presented these findings to Dr. Daniels and the software team to ensure the these hardware decisions will not negatively affect the software components of this project. As the hardware aspect is coming along without many setbacks, we will be working even closer now with the software team to ensure the printer is calibrated correctly and ready for printing.

## Resource Requirements

Many resources must be acquired in order to complete a functional 3D printer. The three-axis movement system has already been provided to us, along with an Arduino board and various logic circuits used as kill switches for the system. The three-axis movement system provided is also equipped with motors and their respective drivers. The budget for our project is $400, as we have two groups working together simultaneously, each group having a budget of $200.

The resources we require on top of those given are:

- A bench in order to mount the 3D printer and house all electronics
- A dual extruder in order to print two types of material
- An extruder mount
- A heated bed
- Printing materials i.e. PLA filament
- PC in order to write and implement software
- Various electrical components and wires to complete circuitry
- Various temperature and alignment sensors

This is a brief overview of the requirements for constructing the 3D printer. This is not to say that we may require more resources in the future if we happen to run into a problem along the way. The resources we require should be within our budget, but could push the boundaries of our maximum limit. We plan to strategically acquire materials in order to get the most for our money so that we can stay within our financial limitations. Many materials were acquired free of charge, including the PC and Arduino Due.

## Project Schedule

Previously we have used sign up documents to assign specific tasks; however, when other members have a scheduling conflict we will make a substitution on the fly. Also, we have been completing our project deadlines a day before the scheduled completion date to account for any unforseen setbacks.

EE491

Expand Collapse

Start Date: 8/27/2013

End Date: 12/10/2013

Today: 11/15/2013

| WBS | Status | Task Name | Dur. | Start | Finish | Work Days | Used Days | Balance | Resource |
|---|---|---|---|---|---|---|---|---|---|
| **1** | **At Risk** | ***Improve Current Safety System*** | ***11*** | **10/10/13** | **10/21/13** | **8** | | | |
| 1.1 | At Risk | *Improve Current Safety System* | *11* | 10/10/13 | 10/21/13 | 8 | | | *Ross* |
| 1.2 | At Risk | *Improve Current Safety System* | *11* | 10/10/13 | 10/21/13 | 8 | | | *Kyle* |
| 1.3 | At Risk | *Improve Current Safety System* | *11* | 10/10/13 | 10/21/13 | 8 | | | *Cheng* |
| **2** | **On Schedule** | ***Vertical Bench Mount w/ Cable Management*** | ***17*** | **10/10/13** | **10/27/13** | **12** | | | |
| 2.1 | At Risk | *Cable Management Design & Construction* | *17* | 10/10/13 | 10/27/13 | 12 | | | *Jake* |
| 2.2 | At Risk | *Physical Design & Construction* | *17* | 10/10/13 | 10/27/13 | 12 | | | *Andrew* |
| **3** | Complete | ***Install Axis System and Electronics on New Bench*** | ***8*** | **10/27/13** | **11/4/13** | | | | |
| 3.1 | Complete | *Install Axis System and Electronics on New Bench* | *8* | 10/27/13 | 11/4/13 | | | | *Jake* |
| 3.2 | Complete | *Install Axis System and Electronics on New Bench* | *8* | 10/27/13 | 11/4/13 | | | | *Ross* |
| 3.3 | Complete | *Install Axis System and Electronics on New Bench* | *8* | 10/27/13 | 11/4/13 | | | | *Andrew* |
| 3.4 | Complete | *Install Axis System and Electronics on New Bench* | *8* | 10/27/13 | 11/4/13 | | | | *Kyle* |
| 3.5 | Complete | *Install Axis System and Electronics on New Bench* | *8* | 10/27/13 | 11/4/13 | | | | *Cheng* |
| **4** | **On Schedule** | ***Install Extruder on Axis*** | ***8*** | **11/4/13** | **11/12/13** | **7** | | | |
| 4.1 | At Risk | *Install Extruder on Axis* | *8* | 11/4/13 | 11/12/13 | 7 | | | *Jake* |
| 4.2 | At Risk | *Install Extruder on Axis* | *8* | 11/4/13 | 11/12/13 | 7 | | | *Ross* |
| 4.3 | At Risk | *Install Extruder on Axis* | *8* | 11/4/13 | 11/12/13 | 7 | | | *Andrew* |
| 4.4 | At Risk | *Install Extruder on Axis* | *8* | 11/4/13 | 11/12/13 | 7 | | | *Kyle* |
| 4.5 | At Risk | *Install Extruder on Axis* | *8* | 11/4/13 | 11/12/13 | 7 | | | *Cheng* |
| **5** | **On Schedule** | ***Design Power Distribution/Heat Bed w/ Leveling System*** | ***50*** | **10/21/13** | **12/10/13** | **37** | **19** | **18** | |
| 5.1 | On Schedule | *Design Power Distribution/Heat Bed* | *50* | **10/21/13** | **12/10/13** | 37 | | 18 | *Kyle* |
| 5.2 | On Schedule | *Design Power Distribution/Heat Bed* | *50* | **10/21/13** | **12/10/13** | 37 | | 18 | *Cheng* |
| 5.3 | On Schedule | *Design Power Distribution/Heat Bed* | *50* | **10/21/13** | **12/10/13** | 37 | | 18 | *Ross* |
| **6** | **Complete** | ***Complete Final Project Plan*** | ***33*** | **10/10/13** | **11/12/13** | | | | |
| 6.1 | Complete | *System Block Diagram & Project Schedule* | *33* | 10/10/13 | 11/12/13 | | | | *Jake* |
| 6.2 | Complete | *Functional and Non-Functional Requirements* | *33* | 10/10/13 | 11/12/13 | | | | *Ross* |
| 6.3 | Complete | *Deliverables & Work Breakdown Structure* | *33* | 10/10/13 | 11/12/13 | | | | *Andrew* |
| 6.4 | Complete | *Resource Management & Risks* | *33* | 10/10/13 | 11/12/13 | | | | *Kyle* |
| 6.5 | Complete | *Problem Statement* | *33* | 10/10/13 | 11/12/13 | | | | *Cheng* |
| **7** | **On Schedule** | ***Complete Final Design Plan*** | ***61*** | **10/10/13** | **12/10/13** | **44** | | **18** | |
| 7.1 | On Schedule | *TBD* | *61* | 10/10/13 | 12/10/13 | 44 | | 18 | *Jake* |
| 7.2 | On Schedule | *TBD* | *61* | 10/10/13 | 12/10/13 | 44 | | 18 | *Ross* |
| 7.3 | On Schedule | *TBD* | *61* | 10/10/13 | 12/10/13 | 44 | | 18 | *Andrew* |
| 7.4 | On Schedule | *TBD* | *61* | 10/10/13 | 12/10/13 | 44 | | 18 | *Kyle* |
| 7.5 | On Schedule | *TBD* | *61* | 10/10/13 | 12/10/13 | 44 | | 18 | *Cheng* |

## Risks

**Physical:**

The construction and operation of a 3D printer involves many risks that one needs to be aware of. When working with electrical components, there is always a risk of shock. This holds true in our case, especially since we will be dealing with a system with a relatively high power consumption operating at a high voltage. The heating systems are a potential risk as well since they will require a higher current, therefore making them more dangerous. The heating components not only pose a risk for shock, but also a risk of burning oneself. The extruder alone operates at points well above 200 degrees Celsius, which can easily burn skin upon contact. Also, the heated bed implemented into the system can pose a burn risk, since the surface area will be fairly large, and will operate at fairly high temperatures. There is a risk for injury if the system was to ever tip over. The three-axis movement system alone is over 100 pounds, which is more than enough to injure a body part if the system were to fall on it. Last, when operating the 3D printer it is important to keep all parts of the body clear of the system, since the moving parts of the printer are a potential risk for injury.

**Non-Physical:**

Physical risks are important to consider, but just as important are non-physical risks. One major risk any team faces when engineering a project is the risk of failure. By having a solid plan and implementing this plan, the risk of failure is lowered significantly. Another risk to consider is that of going over our given budget. This is a potential risk since 3D printers require accurate components, which can have a high price tag. Not only are these components expensive, but many different components are required to complete the project, further heightening the overall cost.