Automatic Solder Dispenser

PROJECT PLAN

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ETG: Electronics and Technology Group

ISU: Iowa State University

Coover Hall: The dedicated electrical and computer engineering hall at Iowa State University

PLC: Programmable Logic Controller

HMI: Human Machine Interface

ID: Identification

1 Introductory Material

1.1 Acknowledgement

The team would like to thank the Coover Hall ETG Department at Iowa State University. Without their assistance and funding, this project would not be possible. We would like to specifically thank Leland Harker, our client and advisor. He has a great passion for engineering and is more than willing to share his knowledge and resources with us.

1.2 Problem Statement

ETG has seen an increase in solder use in Coover Hall. Students will come to ETG asking for solder, but often don't know what kind they should be using. An ETG employee would then explain the different types, help the student decide which one is best for their unique situation, and give them approximately 12-18 inches of the requested solder. This is a very frequent and repetitive occurrence. ETG has requested that an automatic solder dispenser is designed and created to allow more efficient allocation of ETG employee time.

ETG also wants the dispenser to be small enough so that it can be moved to different labs where students may need solder. Since the purpose of the dispenser is to give students solder while saving ETG time, it needs to be user friendly and easy to operate for students. Another problem ETG has is that they do not want students to waste solder. For this reason, the dispenser must incorporate a feature that will not allow students to have access to an unlimited amount of solder.

Since the dispenser will be in labs and not in the ETG room, administrators from ETG will not be able to monitor it. This means that ETG will not be able to know if students are trying to manipulate the dispenser into giving them more solder. For example, students may try unplugging the machine, deleting the memory, or simply trying to pull more solder out of the dispenser itself. The dispenser needs to be able to protect itself from students who try to use it outside of its intended functionality.

Another feature that the client wants is to give the students an opportunity to see how the dispenser works during its operation. Both the mechanical and electrical functionality of the dispenser needs to be displayed for the students. The ultimate purpose of this feature is to expand the learning experience of the users.

The dispenser also needs to recognize when an administrator is present and performing maintenance on the device. For example, the dispenser needs to allow administrators to check how much solder is left inside in case they need to replace rolls of solder. Also, the machine needs to be able to communicate with ETG if problems are encountered during

the operation of the device. Examples of issues the dispenser may have include jams or when solder rolls are getting low.

1.3 Operating Environment

The automatic solder dispenser will be located in various labs in Coover Hall. The dispenser must be strong and enduring, because malicious engineering students will tend to hit and tilt the machine. Special care must be taken to ensure that the machine is not easily damageable and that normal wear will not interfere with its functionality. There will not be any harsh precipitation or temperature changes, and the labs are generally kept clean.

1.4 Intended Users and Intended Uses

The automatic solder dispenser will have to main users: students and administrators. Students will be in need of solder throughout the semester, and this machine needs to be easily accessible for those in need of solder. Students will swipe their ISU ID, navigate through the solder descriptions, decide which solder type is best for them, and select it.

Students will benefit from this machine due to it being accessible at all hours, every day. Currently, if a student is working on a project late at night and needs solder, the student would be out of luck because ETG would be closed.

Administrators will care for the machine and replace solder rolls when needed. The administrators will be ETG employees, and they will receive emails when the machine jams or needs a roll replaced. They can then swipe their ISU ID card into the machine and gain access to the administrator page on the touchscreen. Here they can view usage rates and errors, and they can notify the machine when a solder roll has been replaced.

1.5 Assumptions and Limitations

Assumptions:

- Multiple solder dispensers will eventually be created using our designs.
- If multiple dispensers are made, students will only be locked out of the individual machine they used for 20 minutes.
- Multiple rolls of the same type of solder will not be placed in one machine.
- 120V AC will be available for the dispenser to use.

- A stand or table will be available for the dispenser to sit on in order to be at customer level.

Limitations:

- Each student will need their ISU ID card present when needing solder.
- The cost of each solder dispenser will be several hundred dollars.
- Changing the structure of emails or programming will be difficult for those unfamiliar with the software.
- The size of the box should be approximately shoe-box sized.

1.6 Expected End Product and Other Deliverables

The final deliverables for this project will include one fully-working solder dispenser machine, as well as the necessary designs needed to create additional dispensers in the future. The solder dispenser will be fully operational and tested. It will be tested by allowing students to use it for several weeks during the spring. The dispenser should be completed and ready to be tested by March 18, 2019. The final version with any corrected pieces or parts should be completed by April 15, 2019. The finished project will be able to function correctly for both students and administrators. Other deliverables include documents for the recreation of the solder dispenser.

The main user for the solder dispenser is students. The final function of this project for students can be summarized in a few steps. First, the student will swipe his or her student ID. Then, the student will use the touch screen to select what type of solder he or she would like. The machine will then cut a piece of solder for the student and not allow him or her to get more solder for 20 minutes.

The other intended user is an administrator. The finished project will function differently for administrators than for students. After the administrator swipes his or her ID, he or she will be allowed to view usage statistics or perform maintenance on the machine. The finished project will also be expected to communicate with administrators as well. Errors such as jams and warnings about low solder rolls with be emailed to administrators from ETG.

Besides the expected functionality of the project, the designs for the dispenser will also be delivered. The designs to be included in the final project will consist of circuit schematics, layout designs, codes, and parts lists. The layout designs will include an assembled layout of the box. Using this information, more dispensers can be created in the future.

2 Proposed Approach and Statement of Work

2.1 Objective of the Task

The objective of this project is to design and create and automatic solder dispenser. This machine can be used by anyone with an Iowa State University ID card to obtain solder. The designs will be included for future scaling purposes, as ETG may wish to create more machines.

2.2 Functional Requirements

The functional requirements are broken up as follows for student and administrator users:

Students

- Display screen will inform students about solder types
- Display screen will allow students to pick a type of solder
- Box will dispense 12-18" of solder from the specified roll
- Box will cut solder piece off before student receives it
- Box will sense if an error has occurred.

Administrators

- Administrators can view solder levels for each roll
- Administrators can inform machine of a changed roll
- Machine will send periodic emails of usage rates and levels
- Machine will send an email when roll has approximately 5% remaining
- Machine will send an email when a jam has occurred

2.3 Constraints Considerations

The total cost of the box should be less than $400. This constraint will limit what components and enclosures we use. The box should be approximately the same size as a standard shoe box, and should have a clear top for students to see inside and understand what is going on inside the dispenser. The user screen should display information about the different solder types available and students should have no issues figuring out how to use the dispenser. None of our practices should be considered unethical, and all code will be neatly written and follow standard coding practice.

2.4 Previous Work And Literature

Leland Harker, our client, had already drawn up and created several mechanical designs, including a solder extruder and servo cutting system. He gave us the assembled Inventor drawings, extruder, and cutter, and we now have to ensure that each will work correctly as well as designing the other components to integrate seamlessly with it.

As far as we know, an automatic solder dispenser has not been created by anyone in the past. Similar designs exist, including a vending machine for electrical components, but our machine is different in that it is free and operates from ISU ID's. It will also have a completely different inside component design, as the vending machine shown (Figure 1) is a standard snack vending machine while our design is specifically made for solder.

Figure 1: Electronic Parts Vending Machine (Bell, 2018)

Although this project is much different than an electrical parts vending machine like in Figure 1, some features will be similar. For example, in order to show students what is going on inside the dispenser, one of the sides of the enclosure will be a clear surface. More specifically, the specified side of the enclosure will act as a window that will allow the user to see all of the mechanical and electrical parts functioning together. Allowing the user to see the functionality of the device is similar to how a vending machine has a clear window like in Figure 1. All of the electrical parts in the vending machine are visible to the user. Also, the user gets to watch the machine dispense the item that he or she wants. This common feature of vending machines will be implemented in the solder dispenser design as well.

Another feature in vending machines that will also be implemented in the design of the solder dispenser is a mechanism that does not allow the user to reach in and take items that he or she did not pay for. In the scope of this project, students should not be able to

reach into the solder dispenser and take more solder than they are allowed at a time. A common vending machine has a door that the user can open to retrieve the items that he or she paid for. The door, in this case, is designed so that the user cannot reach upwards to take more items. Similarly, the solder dispenser will not allow students to reach into the machine and take more solder than is allowed. The student will only be able to retrieve the solder that the machine dispenses for him or her.

Vending machines also require a form of payment before a user can receive an item that he or she wants. This project will implement a similar feature, but instead of using currency to receive the solder, students will swipe their ISU IDs. Additionally, each student can swipe his or her card only once every 20 minutes. Requirement of a student ID as well as a time limit compared to use of currency to operate a vending machine.

2.5 Proposed Design

We divided this project into three main categories: electrical work, programming, and mechanical work.

Electrical Work

The electrical work will oversee the power requirements for the dispenser, determine which microcontroller is best, design and create a PCB circuit board containing drivers, and determine which servos and motors to use. The electrical team decided to use a Raspberry Pi for the microcontroller, which uses 5V for power. From previous designs and input from the client, it was decided that 2 standard servos will be used for cutting the solder, and 4 stepper motors will be used for pulling the solder off of the roll. Each of the 4 stepper motors will control its own motor. Each motor will control how much solder is being removed from a spool.

The PCB circuit board will have four Adafruit TB6612 stepper motor drivers, one for each stepper motor. It will also contain pins for power, servos, and future sensors. All of these pins are to be placed on the board for organizational purposes. It would be best if as many electrical connections as possible were made on the board. This makes it easier for troubleshooting when testing. Keeping all of those connections on the board will also help others to understand the project, if the dispenser is to be replicated.

Besides pins for power and servos, the board will also have pins for future sensors. These future sensors may be implemented to inform administrators when the box is opened, as well as determining when a jam has occurred.

Programming

On the programming side, a database will be created to store the ISU card numbers of users, which will be read from a USB magnetic stripe reader. By using the database, the dispenser can prohibit users from getting more solder within the next 20 minutes. The

program will be written to control both the stepper and servo motors. The stepper motor can be rotated a specific number of degrees, which will allow us to dispense a preset length of solder. The servo motors will be used to cut the solder.

We plan to use a 7" touchscreen display with the Raspberry Pi, which will be programmed so that users can operate the dispenser and administrators can replace spools and view status reports.

Mechanical Work

The mechanical engineer will determine what designs have already been created, as well as determining if the designs work correctly and are optimal. Four extruders will be created, which will each connect to a stepper motor, and each motor will control the solder on a spool. The extruder has a spring mechanism in order to keep tension on the solder at all times.

After the extruder piece, a collector will be connected. The collector will combine the outputs of all four extruders into one single output. In order to have only one cutter, all four different solder spools must end up going to the same place, no matter which type is chosen.

Connected to the output of the collector is 12-18 inches of tubing, which will be formed into a tight spiral. when the solder is pushed through the tubing, it will keep its spiral shape. This is optimal for dispensing, since we do not want the user to have access to the solder until after it is cut. The cutter is made up of two servos, with a design very similar to a cigar cutter (Figure 2).

Figure 2: Guillotine Cigar Cutter (Amazon.co.uk, 2018)

After being cut, the solder will fall into a position inside of the box that is accessible to the user. It is important that the solder is cut first in order to ensure that users cannot pull out more solder directly from the spool.

2.6 Technology Considerations

When first confronted with this project, our initial design include a PLC and HMI combination. We have several members in the group with PLC and HMI programming experience, but we found that the cost of buying a quality PLC and HMI would exceed our entire budget. Instead, the Raspberry Pi can provide the same function for a fraction of the price, and one of our members has experience programming with it.

2.7 Safety Considerations

Safety is important to consider for our dispenser. We have a sharp cutter in motion that could easily do significant damage to appendages if used improperly. To ensure that no user is injured from use or curiousity, the cutter should be inside the box and out of reach.

We will also have 120VAC coming into the dispenser through a wall outlet. We must be careful to wire all components correctly, and ensure that no bare wires can short or be touched by users or administrators.

2.8 Task Approach

During one of the first few meetings our team held, we discussed a plan of action and created the flowchart seen in figure 3.

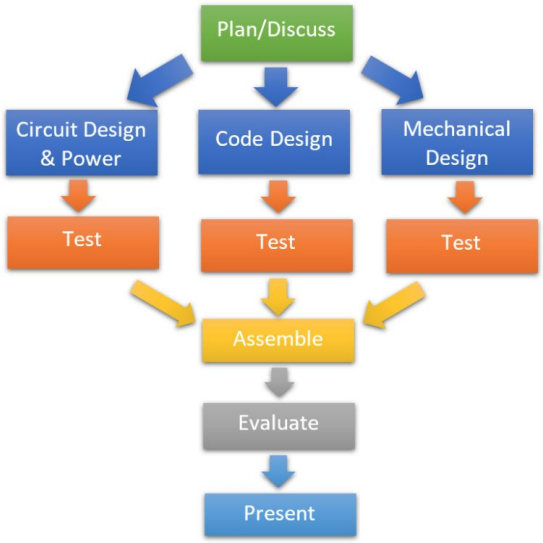

Figure 3: Flowchart of Action

As you can see, we will first go through a planning and brainstorming phase. This will include defining the problem and narrowing down possible solutions. Next we will design the necessary circuits, codes, and mechanical pieces that our solution needs. We will test each section, assemble the pieces together, and evaluate the final product as a whole. If needed we will return to the design process and re-iterate until we have a final product that works as required. Finally, we will present our results.

2.9 Possible Risks And Risk Management

Implementing jam detection for our dispenser could be a challenge. Given our budget of $400, finding a sensor that can accurately determine if a solder stream is present could be tricky. To manage this risk, we are looking at possible mechanical solutions to this issue.

2.10 Project Proposed Milestones and Evaluation Criteria

Our project can be broken down into the following milestones:

Milestone #1: Decide microcontroller, box, and motors

Projected date finished: 9/18/2018

The first task for this project is to determine which microcontroller to use, what type of box to use, and what motors are needed. This is basic information that is needed to start the heavy engineering work, and we completed it on September 18, 2018. To test the box, designs were created that included estimate sizes of each component needed. We found

the smallest box available to reduce cost that still fit all of our required components. We tested stepper motors and servos with the Raspberry Pi, and ensured each type of motor would work.

Milestone #2: Design and Create PCB Board

Projected date finished: 11/23/2018

The next milestone is designing the necessary drivers for the stepper motors and designing one PCB board that contains all of the electrical devices needed. After designing the PCB board, a couple weeks will be needed to create it, and we will be able to test it with the stepper motors and servos currently in our possession.

Milestone #3: Complete Mechanical Design and Creation

Projected date finished: 12/21/2018

The mechanical design and creation process has already started, but we most likely will not finish until late December. The mechanical components, including the extruder and collector, can be tested by hand in many cases, as well as with basic programmed code on the Raspberry Pi.

Milestone #4: Complete Programming Code

Projected date finished: 2/8/2019

The software with the screens and Raspberry Pi will be testable with the stepper motors and mechanical pieces we will have created by this time. The touchscreen can be tested largely on its own. The projected finish date is February 8, 2019.

Milestone #5: Integrate All Parts, Place in Box

Projected date finished: 3/1/2019

After finishing the other milestones, the last step is to integrate all of the parts together and place them in the box. We can test the entire dispenser as a whole, and makes refinements if needed.

2.11 Project Tracking Procedures

Our group has a timesheet that keeps track of weekly goals and success. At the beginning of the week, all members state their goals for what they want to accomplish during the week. They strive to accomplish that goal, and they return to the timesheet at the end of the week. They state what they accomplished, how many hours they work, and what they need from other members in order to accomplish their next task.

When it comes time to write reports, this tracking system makes the process smoother by having detailed information all in one place.

2.12 Expected Results and Validation

Our desired outcome is an automatic solder dispenser that works, does not jam often, and is easy to use. When a rare jam does occur, the machine would be able to realize the jam occurred, and send an appropriate email to ETG. New administrators would be easy to add to the database, and spools would be easy to change and replace. This would be a full turnkey solution, and students would not have issues figuring out how to use the machine.

2.13 Test Plan

Once all of the designs are completed for each of the three areas in the project, testing must be done. At Milestone #2, the PCB board will be finished, meaning the electrical side of the project is ready to be tested. Electrical is tested first because the PCB board is to be finished before the software and mechanical designs are completed. When testing the PCB, it will be connected to the microcontroller, motors, and servos, and LCD screen. Power will be connected from the PCB to each component one at a time. This is done in order to ensure that each component can turn on.

While the software and mechanical designs are still in the process of being completed, simple testing with the motors and servos will be performed to make sure that they will function within the system. When mechanical designs are finished, and the parts are made, they can then be tested with the electrical components. Testing this will verify that the system can work at a basic level. The goal at this testing stage is to see if the system can cut a piece of solder of sufficient length. Once the programing is complete, the entire system can be integrated and tested. Here, the software will control the system, and we will test the functionality for both sets of users. Student-use will be tested first, and then administrator-use.

Once a successful prototype is built and tested, it is time to test the dispenser in a real world application. The plan to test the dispenser is to allow users to operate it for several weeks. We will place the dispenser in a popular, public area (For example: TLA in Coover Hall), where students can test the functionality and try to “trick” our machine. Feedback

from the students will be recorded in terms of improvements to make regarding functionality and usability. Any issues will then be fixed. After making improvements to the design, more testing will be done.

3 Project Timeline, Estimated Resources, and Challenges

3.1 Project Timeline

Our detailed project timeline is shown in tables 1 and 2. Table 1 shows our fall semester timeline, which includes selecting initial parts, designing the PCB board, completing a majority of the programming work, and designing most of the mechanical pieces. Our goal is to complete as much of this project as possible early on. Since most projects tend to take longer than expected, we figure allocating extra time will greatly help us if we fall behind.

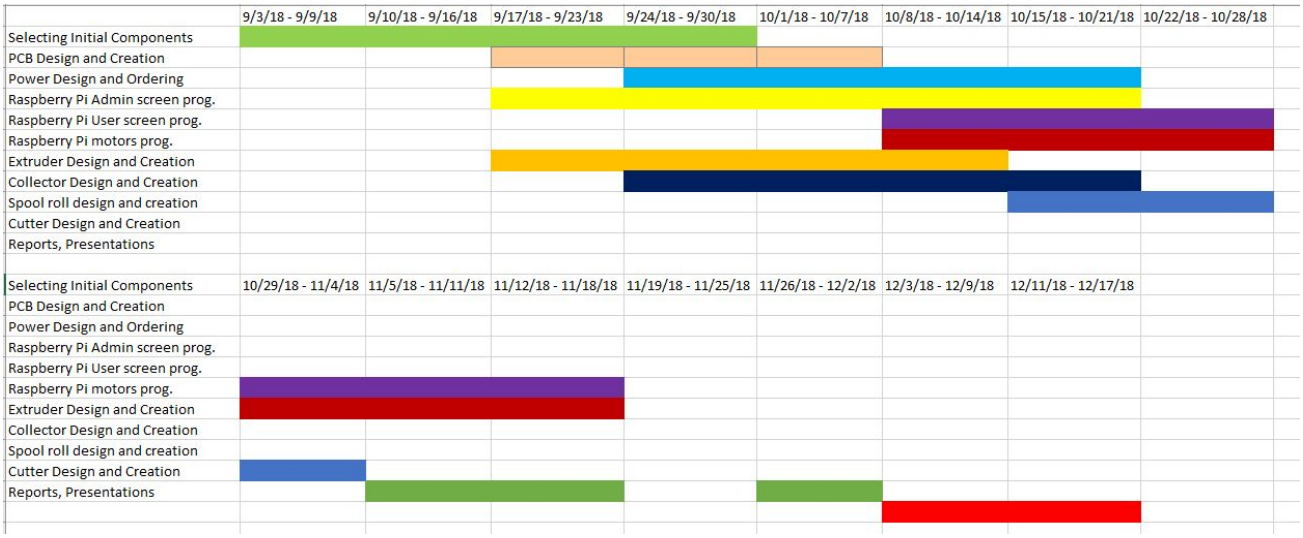

Figure 3: Schedule for Fall Semester

First, initial components will be selected and ordered. While mechanical parts are still being selected, the designs for the PCB will be made. The PCB will be designed using MultiSim and Ultiboard. When the PCB design is finished, the design file will be fabricated.

At the same time as the PCB is being worked on, software will start being written, and the mechanical parts will begin to be designed. The first software to be written is the functionality for the administrator. While the code is being written, the Extruder will be designed. The next software to be written is for the functionality of the user and the touch screen. Programing for the motors will also be done during this time. While this is being

done, the next three mechanical parts will be designed. These parts will be the collector spool roll design, and the cutter. Once the PCB, software, and mechanical parts are finished, the semester will be closed out by working on presentations.

The spring semester (shown in figure 4) will wrap up the programming and mechanical work. We will then spend several weeks evaluating and publicly testing the dispensing machine. If any parts break or wear out we will re-design and test again until the system works well. Finally, we will spend the last couple weeks working on our final presentations and reports.

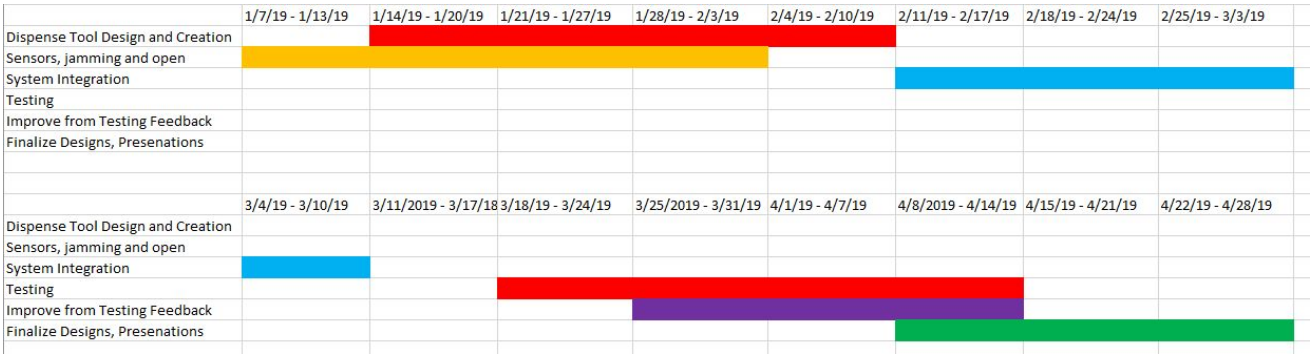

Figure 4: Schedule for Spring Semester

To kick off the second semester, sensors will be implemented to help detect when jams occur. Once the sensors are implemented into the design, the whole system can be integrated. Integrating the system means combining the electronics, software, and mechanical systems in order to form a functioning prototype. When all sections of the project are integrated, testing of the prototype can be performed. After all testing stages are complete, the final design can be made. When the team is satisfied with the performance and functionality of the system, the final presentation will be worked on.

3.2 Feasibility Assessment

We are expected to deliver a fully functioning automatic solder dispenser by the end of the year. The design does not seem too difficult at first glance, but realistically we will likely find that the mechanical side of the project may cause problems. Getting the solder to move smoothly through the dispenser without jamming could be quite a challenge. Then, detecting when a jam occurred could also present some difficulties. We have considered using a light sensor to determine if the solder physically came out of the collector, but that

may not work as well as we imagine. Time will be spent on overcoming this challenge once the first mechanical designs are finished, as this is mostly a mechanical concern.

Figuring out how much solder is left in a roll could also present some challenges. We plan on using a stepper motor and calculating how much solder has been displaced since the roll was installed. Once the roll gets down to approximately 5% of its original length, an email would be sent out to ETG explaining which roll needs changed. We may have to do some slight tuning for this, as we may find that our calculations are slightly off due to slack in the solder. Overcoming this potential issue can be worked on after the PCB is finished. Although the software controls the system and is not yet completed, simple programing can be written to figure out how to detect low solder amounts. When the method for overcoming this issue is finalized, it will then be shared with the programing lead so that it can be implemented with the rest of the software.

Overall the project will likely present some unseen problems, but if we plan ahead and stay on schedule we should be able to handle each one. We should be able to finish this project.

3.3 Personnel Effort Requirements

After meeting as a group, we estimated the number of hours needed for each task and placed the estimations in table 1. The person mentioned for being responsible is not the sole member responsible and/or working on a the given task.

Task	**Total Man Hours Needed**	**Main Person Responsible**
Selecting Initial Components	20	Sam
PCB Design and Creation	30	Trent
Power Design and Ordering	10	Zach
Raspberry PI Admin Screen Programming	25	Jason
Raspberry PI User Screen Programming	25	Jason

Raspberry PI Motors Programming	20	Jason
Extruder Design and Creation	15	Kevin
Spool Roll Design and Creation	15	Justin
Cutter Design and Creation	15	Justin
End of Semester Reports, Presentations	25	Sam
Dispense Tool Design and Creation	30	Kevin
Sensors: Jamming and Opening	20	Trent
System Integration	25	Justin
Testing	8	Zach
Improve from Testing Feedback	30	Jason
Finalize Designs, Presentations	35	Sam

Table 1: Approximation of Time Allocation

Table 1 is only an estimation. As we continue with the project we will likely find that some tasks require much more time while others do not require as much as we suspected.

3.4 Other Resource Requirements

Other than financial resources, our project will need the use of ETG's milling machines for the extruders and collector pieces. We will need aluminum for these parts, as well as a human resource that can operate the mill. We will also need a Raspberry Pi and a 7" touchscreen display, which ETG has in their possession.

We need all of the mechanical designs and prior attempts of extruders, collectors, and cutters that have been made by members of ETG, along with the proper human resources to help us understand the designs.

We will need access to the proper tools for drilling and screwing our box and components together. Most importantly, we need time allocated from our client and advisor to give insights and clarify issues.

3.5 Financial Requirements

To create the solder dispenser, we will need financial resources for the box, PCB board, magnetic card reader, power supplies, and various sensors, cables, and tubes. The approximate box cost will be $100. The other supply costs are unknown at this time, however, our client gave us an approximate budget of $400.

4 Closure Materials

4.1 Conclusion

In conclusion, our project is to create a machine that dispenses 12-18" of solder for university students. This project is important because students are often working in labs late at night when ETG is closed. If they are need of solder, they must wait until the next morning to receive some from the ETG department. Installing a soldering dispenser machine would ensure that students can receive solder at all hours of the day without entire rolls being wasted or stolen.

Our goal is to complete the dispenser, test it, and tune it to where it works with minimal errors. We will then ensure our designs are clear enough that future solder dispenser machines can be created. We will follow our weekly project plan carefully to ensure we stay on schedule and avoid gridlocking each other's work. The machine will have a clear top, and students will be able to see the mechanical and electrical parts, and understand how the machine operates.

We plan to use a Raspberry Pi controller with a 7" touchscreen display to control and extrude solder from the user-selected roll. Four different kinds of solder will be present in the machine, and students can decide which type of solder they need based on the information given on the touchscreen.

This project will be a learning opportunity for all, and will result in a much-needed machine.

4.2 References

Bell, J. (2018). Makerspace Vending Machine. [online] Instructables.com. Available at: https://www.instructables.com/id/Makerspace-Vending-Machine-at-the-Brown-Design-Wor/ [Accessed 26 Sep. 2018].

"Guillotine Cigar Cutter: Amazon.co.uk: Garden & Outdoors." Dorling Kindersley Science Encyclopedia: Amazon.co.uk: Dorling Kindersley Publishing: 9780751356410: Books, www.amazon.co.uk/Oval-Shaped-Cigar-Guillotine-Cutter/dp/B000H681DK.