THE UNIVERSITY OF BRITISH COLUMBIA OKANAGAN CAMPUS

FACULTY OF APPLIED SCIENCE, SCHOOL OF ENGINEERING

VANT151

MULTIDISCIPLINARY ENGINEERING DESIGN PROJECT

PRELIMINARY REPORT

TEAM 6

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ENERGY RECOVERY CLOTHES DRYER WITH EASY OPERATION

CONTENTS

EXECUTIVE SUMMARY

The project is to create an energy recovery clothes dryer in a period of two months. It involves several tasks from electrical wiring, Arduino coding and 3D mechanical design to physical assembling. The electrical wiring includes connecting different parts together such as power supply, LCD, fan, motor and heater on the breadboard. The coding is the core to achieve multi-functions: time, motor speed, temperature and humidity display on LCD and controlling mode and settings. The 3D design relies on a software---Solidworks where the drawing of components and the overall prototype of dryer is conducted. Sometimes to fit the actual size, the actual assembling may be modified and adjusted from the preliminary design. One important feature of this dryer is its sustainability. It recycles the steam after drying and condenses it to liquid phase which will come into another cycle. It saves both water resources and energy at the same time compared with traditional clothes dryer.

ACKNOWLEDGEMENTS

On behalf of Team 6,

I would like to express sincere thanks to our professor Dr. Ernest Goh.

I would also like to express heartfelt thanks to out teaching assistant Delun Chan.

My appreciation also goes out to all those who have helped me at some time or other

English instructors who have provided language support to our team.

Last but not least, I would like to thank UBC to afford all the cost of tools and equipment.

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NOMENCLATURE AND LIST OF SYMBOLS

C	Celsius
H	Humidity
mm	millimeter
L	litre
T	Temperature
V	motor speed
V_o	Volume
rpm	round per minute

CHAPTER 1. INTRODUCTION

1.1 BACKGROUND

The dryer uses a fan and an electric heater to heat clothes. Dryers are common in almost every household in most western countries and humid areas. In this way, the total energy consumed by the dryer is not negligible.

The current cloth dryer use technology like electronic control center, which can collect the instructions from the users through the buttons. Based on the instruction from the users, the cloth dryer will work automatically.

1.2 OBJECTIVES

The project will manufacture a prototype of cloth dryer following the task schedule with the help of software like Solidworks, equipment like 3D printer etc.

1.3 REPORT OUTLINE

This report is divided into 6 chapters which are briefly described below.

1) Introduction.

The brief introduction of the product of project and overall objectives

2) Project Requirements.

Design in prototype to simulate the model clothes dryer

3) Alternative Designs.

Beyond the most satisfying designs, it will show some other creative designs at the beginning of the project

4) Test Results and Discussion. (Will show in the final report)

The results of what will be shown on the LCD screen and the actual performance of the product will be examined.

5) Project Management Plan.

The schedule of project and the detailed information of division of work

6) Conclusion & Future Work.

The conclusion of how the product will perform will be mentioned. As the main objective, sustainability about the future product like the dryer will be invented.

CHAPTER 2. PROJECT REQUIREMENTS

2.1 PROBLEM STATEMENT

Household appliances have the problem that the efficiency of energy use is low. This could be owing to the lack of energy recovery system. Also, traditional dryer cannot meet the requirement of sustainability because resources and energy waste a lot. Therefore, focusing on energy efficiency of clothes dryer and reuse the resources and energy is to demonstrate environmental responsibility.

2.2 FUNCTIONS, OBJECTIVES AND CONSTRAINTS

2.2.1 FUNCTIONS

An opening door was designed to allow clothes in and out. Overall 5 buttons were used to control basic settings and displays on the LCD screen. Electric resistance wire was designed as heater. Motor and fan were used to speed up the process of drying. And a removable water collector is on the right panel.

2.2.2 OBJECTIVES

The most important propose is to short drying time. On this basis, the efficiency of cloth dryer is supposed to be as high as possible. In addition, it also aims at save the waste of heat and lower the cost.

2.2.3 CONSTRAINTS

1.The proportion of each component is limited by the materials and conditions. Only PLA and ABS are available to fabricate certain parts, which makes the prototype perform differently compared with real model.

2. The size of the clothes dryer was set by customers, which is conflict to the size we designed.

3.The capacity of the clothes dryer is not very big.

In the next section, there are some alternative designs introduced that all meet the project requirement.

CHAPTER 3. ALTERNATIVE DESIGNS

3.1 DRUM SIZE

Other Drums Size:

	1	2	3	4	5
Diameter (mm):	121.4	74.4	65.3	90.3	86
Length (mm):	115.3	103	141.2	130	141

Drum size 1: The diameter of this drum is too much big to fit the Air Duct.

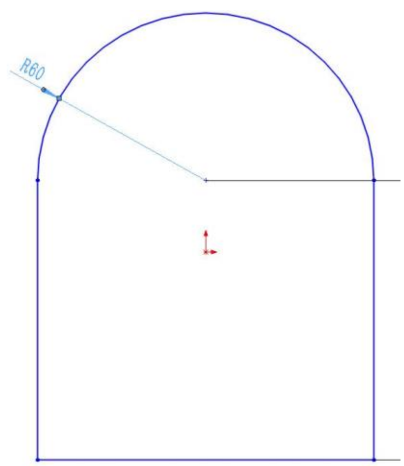


Figure 1. First design

Drum size 2: The diameter is too small to contain both the copper tubes and the heater, because the minimum requirement for the diameter of drum is 80mm.

Calculation:

diameter of copper tube: 6.35mm

distance between two copper tubes: 12mm

diameter of the heater: 61mm

$$6.35+12+61=79.35mm>74.4mm$$

Drum size 3: The same issue as the size 2

Drum size 4: The drum is quite long, which is too big to put inside of the box.

Here are the sizes of drum collected by group members. The final choice of drum is the 5 which has as 86-millimeter diameter and 141mm length as shown in the picture.

Figure 2. Actual drum

3.2 USER INTERFACE

The user interface consists of five buttons, LEDs and the LCD screen. The buttons are lined next to the LCD screen. The LEDs are placed inside of the box with the breadboard. Those parts are placed on the top panel.

3.2.1 VISUAL DISPLAY

For the user interface, the initial design was that the buttons were placed beside the LCD screen in the shape shown on the sketch.

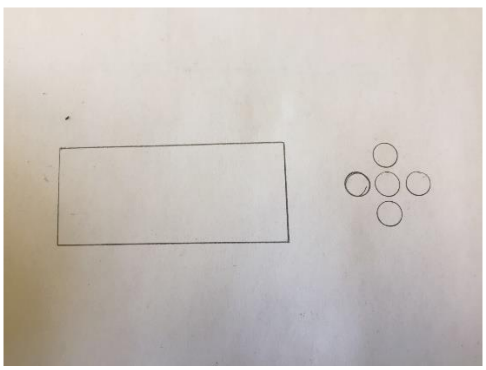


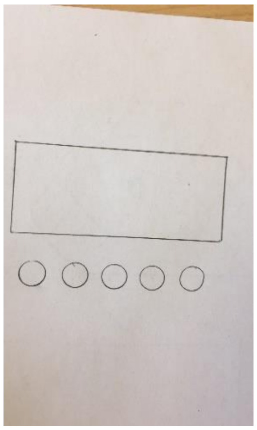
Figure 3. Initial design of top penal

However, due to the limitation of the size of the breadboard, this design was dropped. Therefore, all the buttons beside the LCD screen are placed in the line shape.

According to this design, there is a nearly 10mm separation between each button, and the size of the LCD screen is 50mm length and 100mm width.

3.2.2 MEANS OF INPUT

According to the criteria, the two standards are followed for the design of user interface, minimizing the occupied space and simplification of the Arduino circuits.



The size of the opening for the LCD screen on the top penal is 50mm length and 100mm width. The distance between each button is 20mm, and the opening for each button is the circle with 6mm radius.

3.2.3 ANY OTHER ELEMENTS OF THE USER INTERFACE

3.3 OTHER COMPONENTS/SUBSYSTEMS

For other alternatives, the motor has been tried to put behind the Air Duct in order to let the drum rotate without belts. However, once using this design, the design for Air Duct would be extremely complex, thereby that the idea was deprecated.

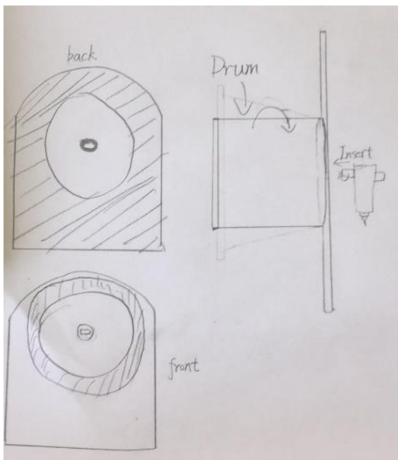


Figure 4. Actual design of the motor and air duct

The figure above is the rough sketch for the ideal design for the motor and air duct. Firstly, the air duct was designed to have two flexible parts. One was a plate for connecting with copper tubes and the heater. Because this part has to be static, so a round hole is designed in order to leave some space for the rotation of the motor. Therefore, the plate would not be rotated along with the drum. Additionally, the other part was supposed to be flexible to let the drum rotate. For this purpose, we would like to design a hole, which exactly fits the shape of the motor. However, according to this design, it would cause the thermal dissipation, and also there is no space for putting the motor.

For the criteria, we choose the design mainly based on two standards, the simplified components and the less material consumption.

3.4 USER INTERFACE

By pressing the buttons, drying mode could be set between auto mode and manual mode. The rotating speed can be adjusted from 10rpm to 20 rpm. Apart from the speed, the temperature could also be set from 40 to 90C depending on multiple needs and the clothes for drying. The drying time also varies from case to case.

3.5 SUMMARY OF THE OVERALL DESIGN

In sum, the drum was selected with an 84mm diameter and 141mm length. The buttons are lined up next to the LCD screen, and there is a 2mm separation between each button. The opening for the LCD screen is 50mm length and 100mm width. The air duct is normally designed, which has a 160mm height and a 100mm width.

In the next section, the test results will be discussed.

CHAPTER 4. TEST RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 AUTOMATIC DRYING

a. The function of the automatic drying mode will be used to save the steps when planning to dry clothes.
b. The speed of the fan and motor will work in medium speed (around 15rpm).
c. The time of drying clothes will be set to 30 minutes.
d. The temperature and humidity function will work in normal mode.

4.1.2 DRYING WITH MANUAL SETTINGS

a. The function of the manual drying mode will be used to have multiple combinations function.
b. The speed of the fan and motor can also be adjusted to low and high speed(10 to 20rpm).
c. The time of drying clothes can be set by different needs.
d. The temperature and humidity function also work depending on personal choices.

4.2 DISCUSSION

4.2.1 AUTOMATIC DRYING

The automatic drying mode caters for the need of convenience and efficiency. It does not require much effort. The basic settings are described in the sections above. This mode represents an smart design for different demand.

The problems that happened during the assembly process.

a. The length of one of the corner tube is different from that of the other tubes, so it is challenging to assemble the bottom panel and left panel together.

   Solution: The corner tube is cut a little bit so it can fit the standard length.

b. The size of the hole on the airduct which will be passed through by the transparent tube doesn't fit the hole which is on the HX outlet. The transparent tube may not be assembling perfectly between the airduct and the HX outlet.

   Solution: Not yet.

c. The buttons assembled on the breadboard are oversized compared to the size of buttons on the top panel.

   Solution: Removing the cap of each button to fit the size on the top panel.

4.2.2 DRYING WITH MANUAL SETTINGS

Drying with manual settings is a little more complicated. The targeting customers are those who pay attention to the quality of drying for different clothes. At the same time, there are more options in terms of temperature, time, and rotating speed. Overall, it focuses more on customer experience and comfort.

The problems that happened during the testing process.

a. The LCD didn't work well every time.

   Solution: Examine the coding several times.

b. The system may restart several times as the drying process proceeds.

   Solution: Examine the coding several times.

c. The buttons can only be pressed quickly, otherwise they will not work as we expected.

   Solution: Examine the coding several times.

CHAPTER 5. PROJECT MANAGEMENT PLAN

5.1 OBJECTIVES

To design and make a heat recovery clothes dryer with the size not exceeding 250 x 220 x 300 mm, and the volume should be at least 0.5L capacity and be able to dry a cotton handkerchief within one-hour testing before 3 July 2018.

5.2 FLEXIBILITY MATRIX

The table is to describe the flexibility of this project. The resources have the least flexibility since they are provided by the school. By contrast, scope has the most flexibility because students can have their own designs depending on their schedules. Time is moderate because different groups have different paces and there might be a delay of submission which is a possible case for all the students. One item, in the table, can be compromised if another has to be increased. For example, if the range of resources become smaller, the schedule may be become longer. It is because students may be need more time to find the material to produce their product.

Table 1. Flexibility matrix.

	Flexibility		
	Least	Moderate	Most
Schedule		✓	
Scope			✓
Resources	✓		

5.3 MAJOR DELIVERABLES

The major deliverables of the project are preliminary report, final report, poster, presentation and final dryer.

5.4 WORK BREAKDOWN STRUCTURE

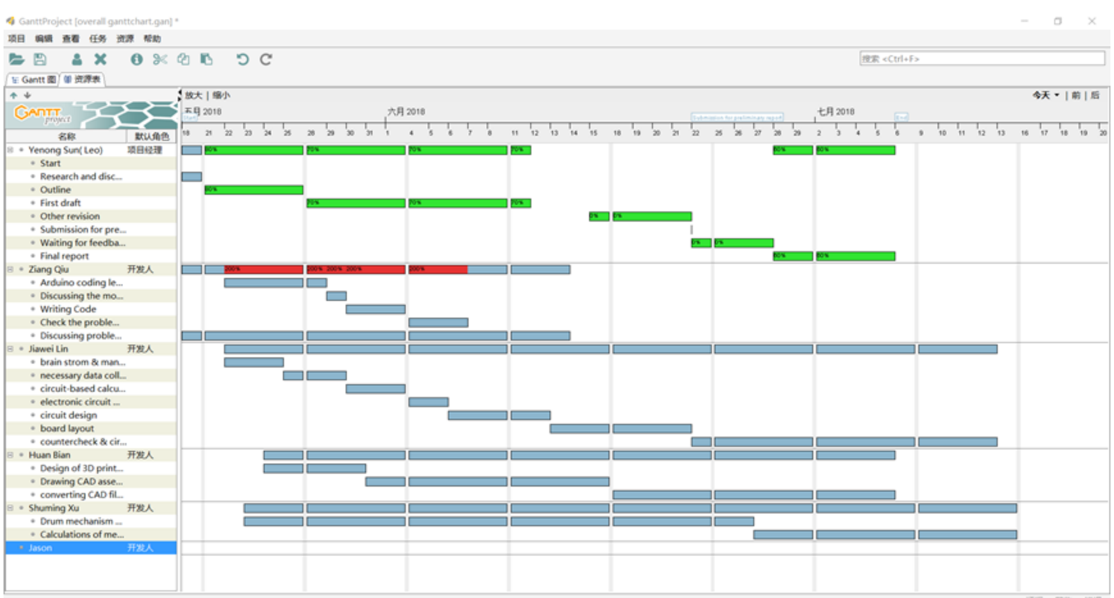
The work was distributed fairly and try to cater for different interests and personal schedule. The WBS of your team Gantt chart is shown as below and in the appendix A.

Untitled Gantt Project

2018-6-23

2

Start	18-5-18	18-5-18
Research and discussion	18-5-18	18-5-18
Outline	18-5-21	18-5-25
First draft	18-5-28	18-6-11
Self revision	18-6-12	18-6-15
Other revision	18-6-15	18-6-21
Submission for preliminary report	18-6-22	18-6-22
Waiting for feedback	18-6-22	18-6-27
Final report	18-6-28	18-7-5
End	18-7-6	18-7-6
Arduino coding learning and review	18-5-22	18-5-28
Discussing the model	18-5-29	18-5-29
Writing Code	18-5-30	18-6-1
Check the problems in the code and revise	18-6-4	18-6-6
Discussing problems with teammates	18-5-18	18-6-13
Design of 3D printed components	18-5-24	18-5-30
Drawing CAD assembly file & drawings of selected design	18-5-31	18-6-15
converting CAD files into 2D drawings with dimensions, tolerances, Bill of Materials, etc.	18-6-18	18-7-5
brain strom & managing ideas	18-5-22	18-5-24
necessary data collection	18-5-25	18-5-29
circuit-based calculation	18-5-30	18-6-1
electronic circuit management	18-6-4	18-6-5
circuit design	18-6-6	18-6-12
board layout	18-6-13	18-6-21
countercheck & circuit board regulate	18-6-22	18-7-12
Drum mechanism of mechanical design	18-5-23	18-6-26
Calculations of mechanical design	18-6-27	18-7-13



1.1. Leo will connect tools and components and organize writing the report.

2.1. Jason and Kyle will do the 3D drawing of the dryer.

2.2. Bruce and Barry will smooth the components to fit into the machine.

3.1. Bruce, Barry, Leo and Oliver will together finish the electrical wiring.

3.2. Leo and Oliver are responsible for the coding.

4.1. All the team members will do the final assembling together.

5.5 OWNERSHIP

In this section, the work that every group member did is shown below in the owner and contributor table.

Tasks / Names	3D Printing	Construct the model	Gantt Chart	Solidworks	Electrical components	Arduino
Bruce	C	O	C	C	O	C
Barry	C	C	C	C	O	C
Leo	C	C	O	C	O	
Oliver	C	O	C	C	O	O
Kyle	O	C	C	O	C	C
Jason	O	C	C	O	C	C

Table 1. Owner and contributors of lowest level tasks.

O---owner: the person who is responsible for the task

C---contributor: the person who contributes to the task

5.6 WBS DICTIONARY

WBS Code	Task Name	Completion Criteria	Owner
1.1	Collect tools and components	Make sure the collection is complete and portable.	Leo
2.1	3D printing external case	All parts of the case printed, post processed and tested to fit together seamlessly.	Jason, Kyle
2.2	Machine internal chassis	All the internal chassis components machined, degreased and tested to fit together properly.	Bruce, Oliver
3.1	Assemble of electrical component	All the circuit well-connected onto the breadboard and Arduino board.	Barry, Bruce, Leo, Oliver
3.2	Coding of Arduino	To show specific words and instructions on the LCD and control the output.	Leo, Oliver
4.1	The assemble of all materials	To assemble each part of the final product.	Bruce, Barry, Oliver, Leo, Jason, Kyle

Table 2. WBS dictionary.

5.7 QUANTIFICATION OF RISK

Some risks remain and may happen during every steps. It is important to avoid those risks.

Risk item	Potential Impact	Likelihood of Occurrence	Difficulty of Timely Detection	Overall Threat
Code mistake	3	5	4	12
The size of each material may not match perfectly and may need to readjust.	4	5	3	12
Missing component	2	4	5	11
Short circuit	3	5	4	12

Table 3. Risk quantification table

5.8 RISK MANAGEMENT MATRIX

To manage and avoid the risks and mistakes, some solutions should be implemented in the following table.

Risk Item	Preventive Action	Contingency Action	Trigger	Owner
Code mistake	Check the code to see if it is able to work or not lots of times.	Check with multiple team members	Code still not working by Jun 30^{th}.	Leo
The size of each material may not match perfectly and may need to readjust.	Before assembling every part together, double check the accuracy of each part.	Check with multiple team members	Assembling still not completed by Jun 30^{th}.	Bruce, Barry, Oliver
Missing component	Check components every week	Buy a new one	It is still missing by Jun 30^{th}.	Leo
Short circuit	Use multimeter to test before plugging	Ask for permission of late submission	It happens before the presentation	Kyle, Jason

Table 4. Risk management table

CHAPTER 6. CONCLUSION & FUTURE WORK

6.1 CONCLUSION

With the two-month hard work, all members in group 6 did the contribution to this project. Basically, some necessary and innovative changes are made compared to original design of the assembly parts. However, there are still some problems in the coding part and assembly part. For the coding part, the group members who are in charge of this will try their best to finish it before JUL 17. But if looking at a broad perspective, the bread board prototype, 3D design and 3D printing were completed successfully. In conclusion, this is a good experience for all of the group members to work as a team and an opportunity to gain a better understanding of sustainability in engineering practice.

6.2 FUTURE WORK

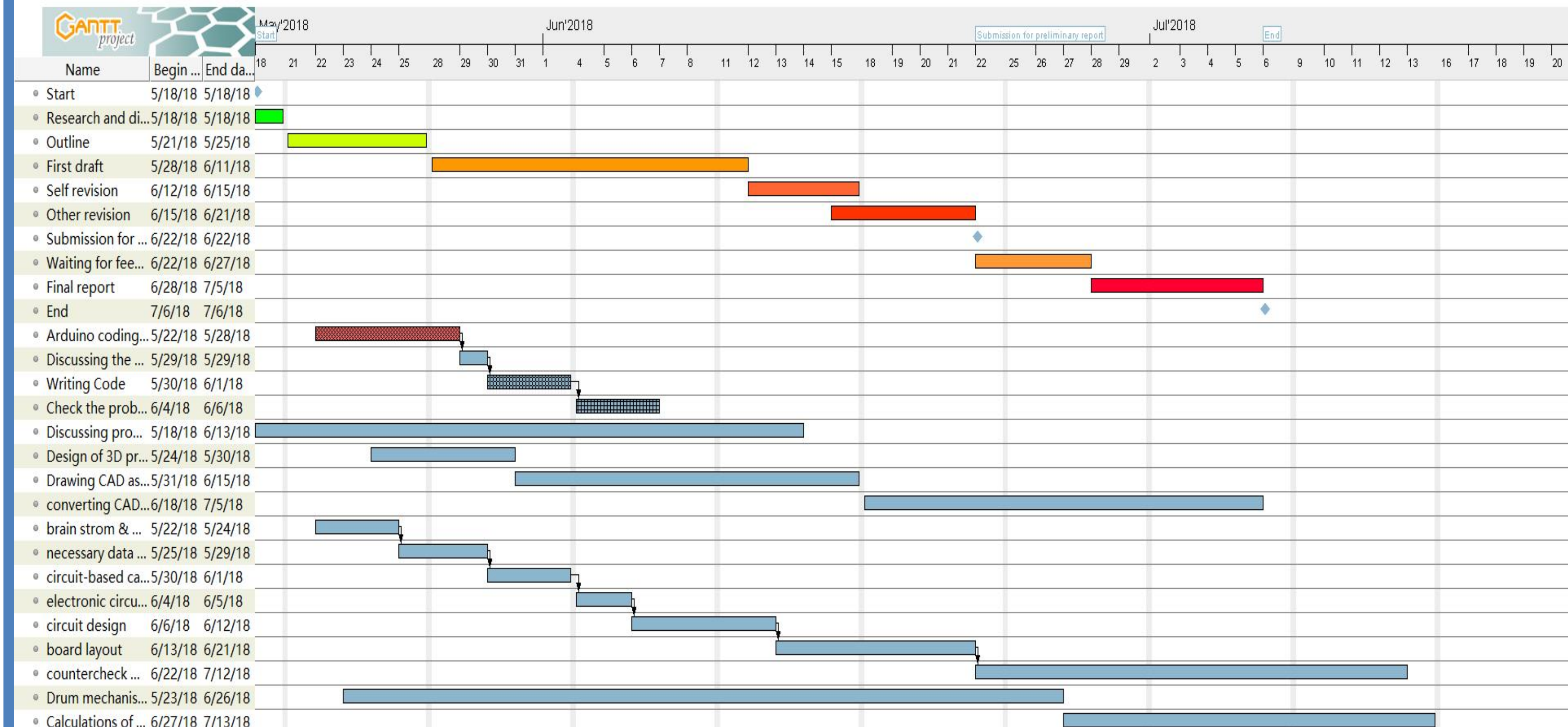
Engineering future

The dryer will be expected to be used in schools, laundry factory and houses. The advantage of our dryer is sustainability. It can save lots of energy through heat recovery. Therefore, its efficiency makes it more marketable in general. Also, the dryer can collect the waste water. The collected waste water can be recycled for further uses. By recycling the water, the dryer can save water resources and achieve sustainability.

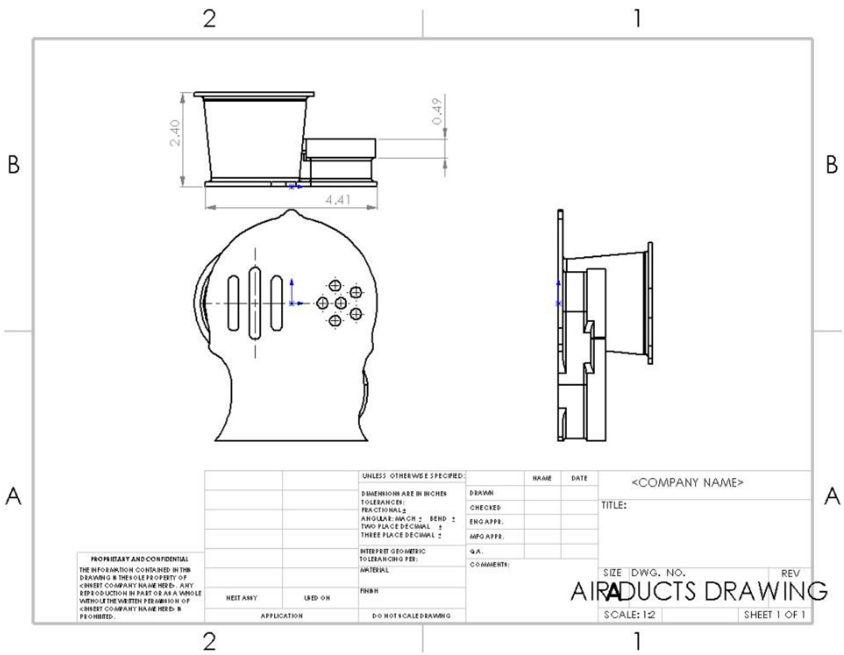
REFERENCES

ENERGY STAR. (2011). Residential Clothes Dryers. Retrieved from https://www.energy star.gov/ sites/ default/files/asset/document /ENERGY_STAR_Scoping_Report_Residential_Clothes_Dryers.pdf

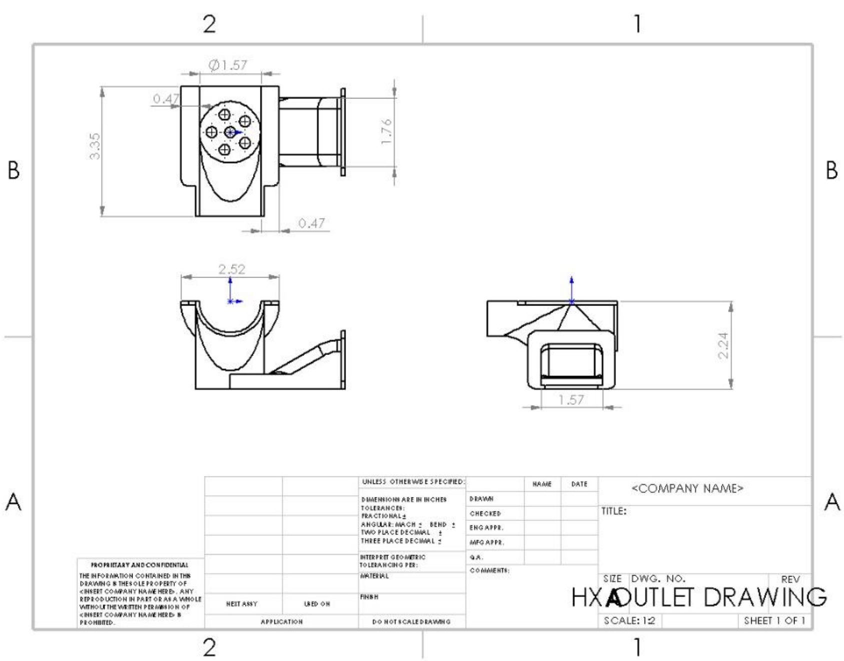
APPENDIX A – GANTT CHART



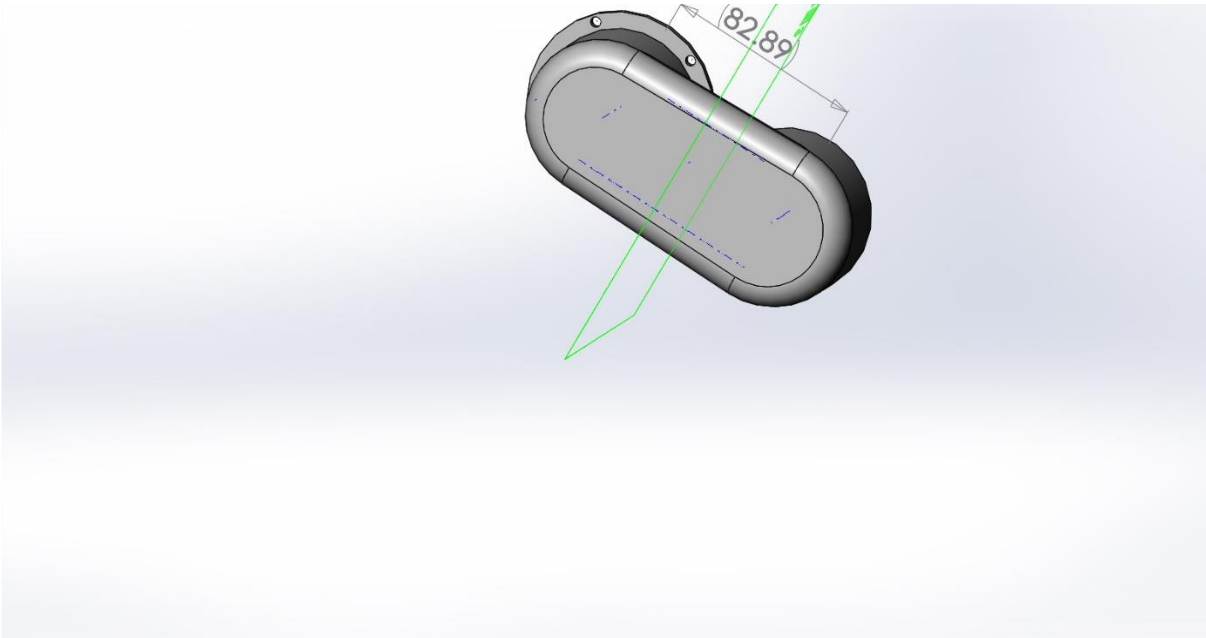
APPENDIX B – CAD DRAWINGS



Air Duct



HX Outlet



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