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IoT Pendaflex

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Joint Engineering Program

University of Missouri–St. Louis ▪ Washington University in St. Louis

ELEVATE YOUR FUTURE.
ELEVATE ST. LOUIS.

The IOT Pendaflex is a homework return system to alleviate the hassle of professors having to coordinate with teaching assistants in order to return homework that has been graded, to students.

JME 4110
Mechanical Engineering
Design Project

IOT Pendaflex

Brandon Armour
Brandon Neptune
Stephanie Niesen

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1 INTRODUCTION

1.1 VALUE PROPOSITION / PROJECT SUGGESTION

Our group believes that an electronically secured mailbox type homework storage system with access via student ID, dedicated keycard, Bluetooth, or phone app would be the best way for students to keep their graded work secure, along with the added benefits of ease of programming and no keys to lose. Students already have their ID card coded to access certain buildings that they are registered for, so it may not be very difficult to add coding for a secure box they can access. Since the design is for one class only, the boxes would not need to be very tall since they will only contain paperwork returned to the student.

1.2 LIST OF TEAM MEMBERS

- Brandon Armour
- Brandon Neptune
- Stephanie Niesen

2 BACKGROUND INFORMATION STUDY

2.1 DESGIN BRIEF

Many WU McKelvey faculty rue the day that we lost the student pendaflexes that allowed us to distribute hardcopy documents such as graded homework and other course related items. The explanation was that we could no longer do this because the traditional pendaflex system that was used allowed students to see the graded work of others. Design some type of IoT (internet of things) pendaflex dedicated to a single instructor. It should allow remote (restriction of) access and enabling of access for certain students.

2.2 BACKGROUND SUMMARY

1. https://safetyletterbox.com/mailboxes/electronic-mailboxes/salto-electronic-mailbox-lock/

The SALTO electronic mailbox is a secure storage solution that combines the benefits of electronic access control with a specifically designed lockable item. The SALTO electronic mailbox features the SALTO XS4 Locker Lock can be integrated into existing SALTO access systems in a project for a comprehensive solution.

The SALTO XS4 Locker Lock uses state-of-the-art access control technology that is managed using software that can authorise individual access rights depending on their specific privileges. Mailboxes that feature the SALTO XS4 Locker Lock can be retrospectively incorporated into existing SALTO locking access control systems.

Figure 1: This system uses a PO box style setup with an RFID access card swiped to unlock the box. This would allow students to securely access their own homework in an electronically controlled box.

3. https://www.florencemailboxes.com/

Figure 2: These PO Box styled/USPS mailboxes could inspire a solution for electronic mail slots for student's homework return. These boxes would require a key for unlocking, which would still work in the circumstance of a power outage; however, these might be less secure due to keys going missing, being copied, or not being returned at the end of the semester or the end of the student's attendance.

4. https://blog.atlasrfidstore.com/7-types-security-attacks-rfid-systems

Security breaches are the biggest concern for an electronic locking system. Security breaches via cloning, replication, and power analysis are all concerns to think about during the design process. Other issues to think about would be power failure and equipment failure causing the entire system to fail. What would we do in the result of loss of power or failure of keypad?

5. https://www2.ed.gov/policy/gen/guid/fpco/ferpa/index.html

FERPA is the biggest code and concern regarding our project. FERPA laws are the reason the pendaflex was taken down. Students over the age of 18 have the right to keep their educational records confidential. This includes grades. Since the pendaflex was open and not secured, any other student, or anyone walking by, could snoop at a student's graded homework.

6. Our group believes that an electronically secured mailbox type homework storage system with access via student ID, dedicated keycard, bluetooth, or phone app would be the best way for students to keep their graded work secure, along with the added benefits of ease of programming and no keys to lose. Students already have their ID card coded to access certain buildings that they are registered for, so it may not be very difficult to add coding for a secure box they can access. The difficulty might lie on the TA or professor returning the graded work back to the student. Names might have to be put on the boxes, in order to locate them. A design consideration would be how to assign the boxes. Would the assignment be random? Should the students be grouped with when they began their attendance at WUSTL? Should they be grouped by junior and senior classes - this would vary with part-time vs full-time students? Since the design is for one class only, a system of alphabetical order by the last name would quickly solve this. The boxes wouldn't need to be very tall, since they will only contain paperwork returned to the student.

3 CONCEPT DESIGN AND SPECIFICATION

3.1 USER NEEDS AND METRICS

3.1.1 Record of the user needs interview

Project/Product Name: RFID Controlled Mailbox			
Customer: Craig Giesmann, JME4110 Professor Address: Washington University Willing to do follow up? Yes Type of user: Engineering		Inteviewer(s): Brandon Armour, JME4110 student Date: 6/24/2019 Currently uses: Old Pendaflex	

Students, TA, and Professors			
Question	Customer Statement	Interpreted Need	Importance
What kind of security would you want this system to have?	Completely FERPA compliant. Only the individual student, TA, and professor should have access to the box.	System needs to be FERPA compliant	5
How big do you need the boxes to be? How large of a stack of papers does it need to hold? Are they all standard 8 ½ x 11 papers?	Needs to hold 8 ½ x 11 paper. Needs to serve at least an entire class if not multiple classes.	Boxes need to be at least 12" x 15" area Boxes should be at least 2" tall TA slot needs to fit standard 8 ½ x 11 paper System needs to hold homeworks for at least a full class	1 1 1 4
Would you leave the mailboxes indoors or outdoors?	Indoors. However needs to be portable. System should also be lockable to another structure without breaking the drywall	Season needs to be reasonably portable System needs to be locked to an existing structure	3 1
Who should be able to access this system?	Only students in the class with assigned boxes, TA, and professor. It should be accessible at all times	System needs 24/7 access	3
Where would you like the card reader to be located on the box?	Does not matter, just easily accessible.	N/A	N/A
What would your ideal access card be? Student ID, RFID, Bluetooth, or phone app?	Student ID please.	Device needs to be compatible with Student ID card	3

Table 1: Customer Needs Interview.

3.1.2 List of identified metrics

Metrics Table for RFID controlled mailbox

Metric Number	Associated Needs	Metric	Units	Min Value	Max Value
1	1	Student ID compatible	Binary	0	1
2	2	Length	in	1	60
3	2	Width	in	1	60
4	3	Box has locks	Binary	0	1
5	4	Weight	Lbs	1	300
6	4, 5	System has wheels	Binary	0	1
7	5	System is secured to another structure	Binary	0	1
8	6, 8	Number of Boxes	Integer	1	100
9	4, 5, 7	System Location	Map Location	Parking Garage	Urbauer
10	3, 7	Wifi access	Binary	0	1
11	8	Height	in	1	60
12	3, 9	Input slot width	in	1	60

Table 2: Metrics

3.1.3 Table/list of quantified needs equations

Needs Table for RFID controlled mailbox

Need Number	Need	Importance
1	Device needs to be compatible with Student ID card	3
2	Boxes need to be at least 12"x15" area	1
3	System needs to be FERPA compliant	5
4	System needs to be reasonably portable	3
5	System needs to be able to be locked to an existing structure	1
6	System needs to hold homeworks for at least a full class	4
7	Boxes need 24/7 access	3
8	Boxes should be at least 2" tall	1
9	TA slot needs to fit standard 8 ½" x 11" paper	1

Table 3: Needs

3.2 CONCEPT DRAWINGS

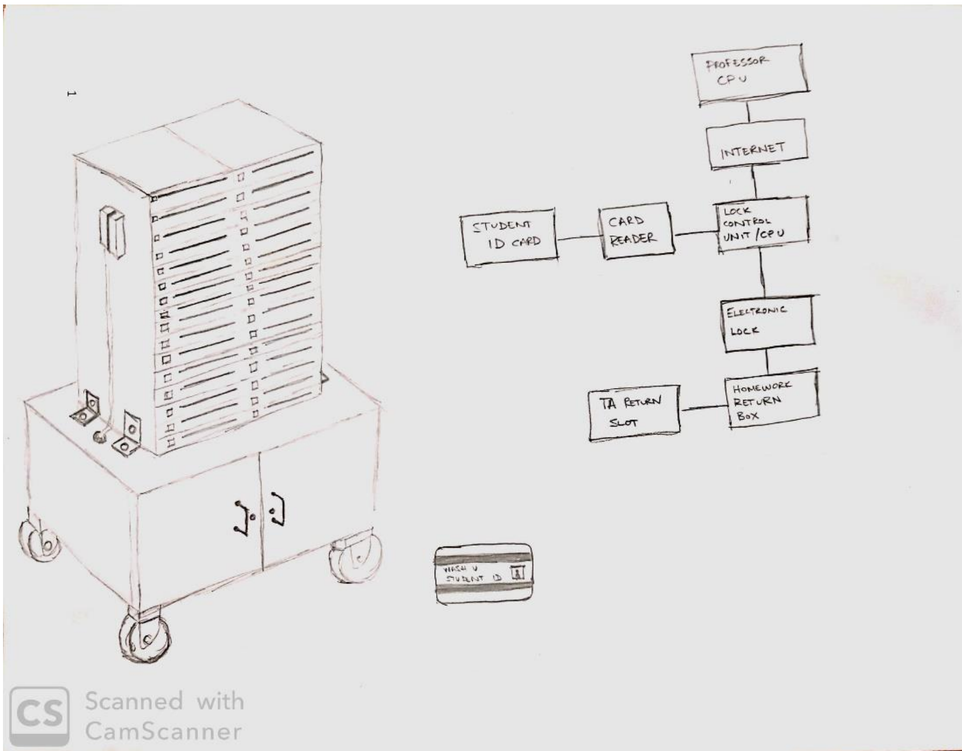


Figure 3: Original Concept drawing 1

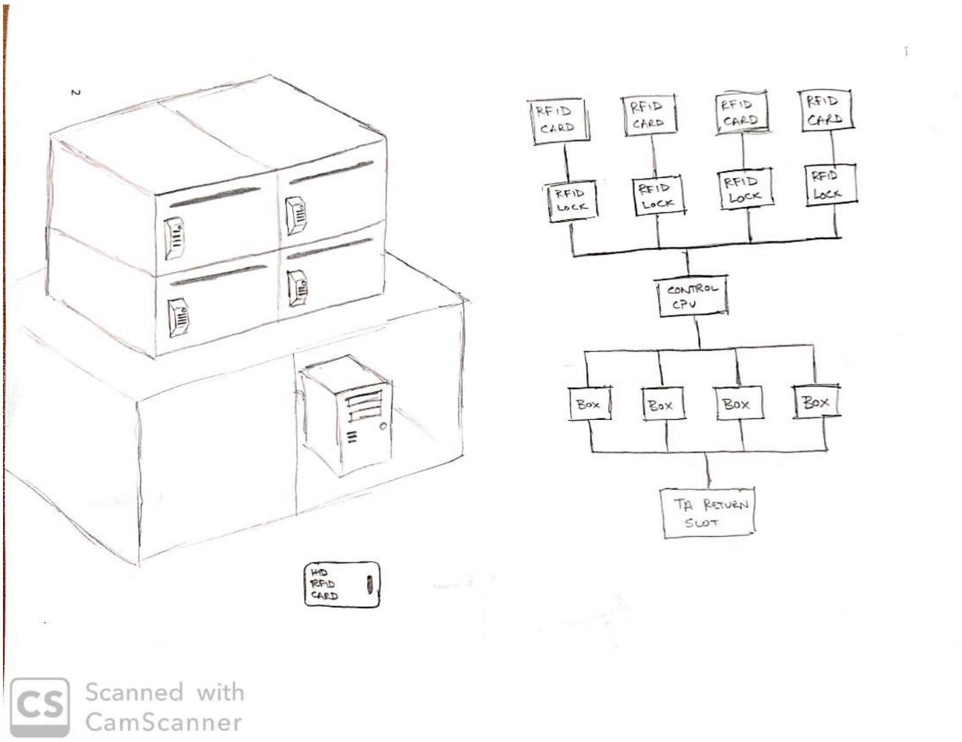


Figure 3: Original Concept drawing 2

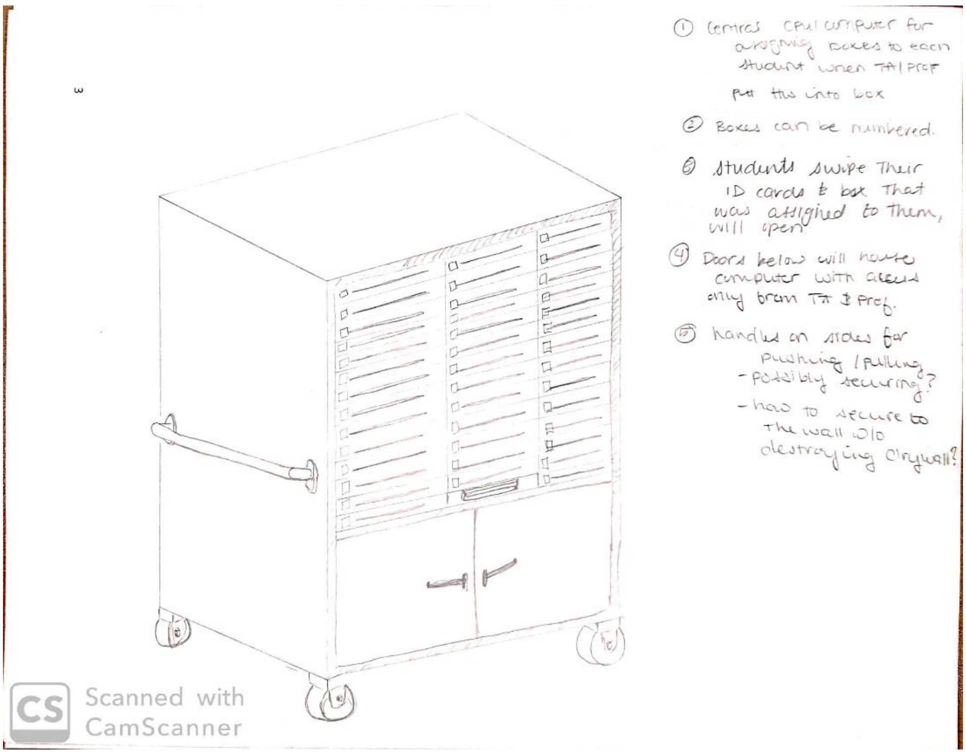


Figure 5: Original Concept drawing 3

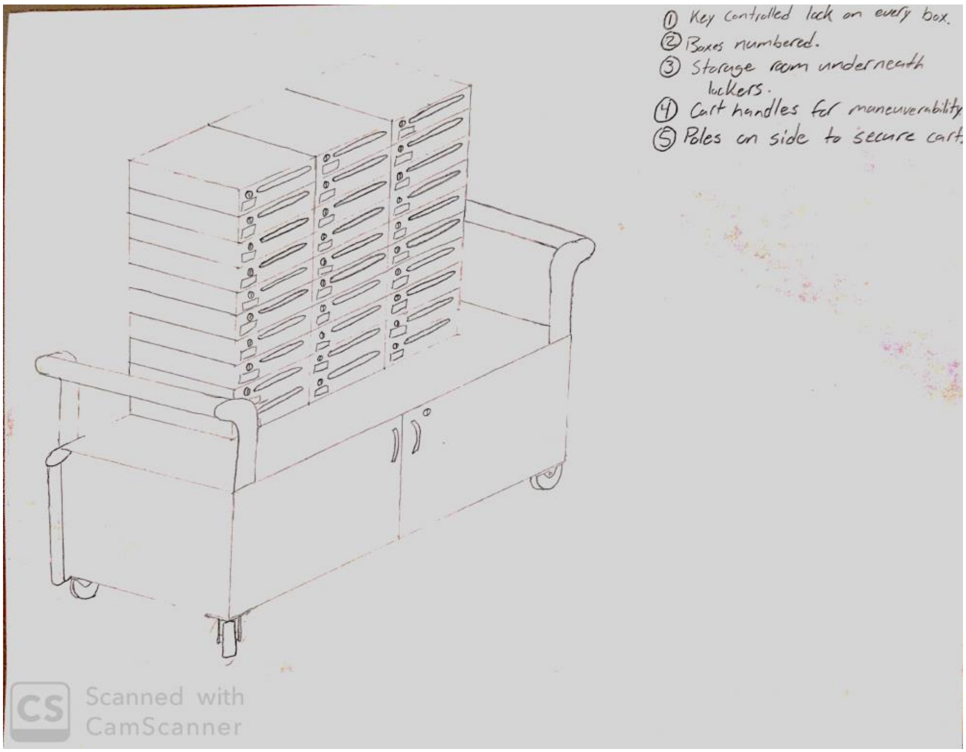


Figure 6: Original Concept drawing 4

3.3 A CONCEPT SELECTION PROCESS.

3.3.1 Concept scoring (not screening)

IoT Pendaflex		Uses Student ID as keycard	Length	Width	Box Locks	Weight	Has wheels	System Secured / Lockable	Number of Boxes	System location	Has wifi access	Height	Input slot width		Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	Device needs to be compatible with Student ID card	1													1	0.1	0.1
2	Boxes need to be at least 12"x15" area		0.5	0.5											1	0.05	0.05
3	System needs to be FERPA compliant				0.7						0.25		0.05		1	0.3	0.3
4	System needs to be reasonably portable					0.2	0.7			0.1					0.964	0.1	0.0964
5	System needs to be able to be locked to an existing structure						0.1	0.6		0.3					1	0.05	0.05
6	System needs to hold homeworks for at least a full class								1						0.3	0.2	0.06
7	Boxes need 24/7 access									0.7	0.3				1	0.1	0.1
8	Boxes should be at least 2" tall								0.1			0.9			0.705	0.05	0.03525
9	TA Slot Needs to fit standard 8 1/2"x11" paper												1		1	0.05	0.05
10															0	0	0
11															0	0	0
12															0	0	0
13															0	0	0
Units		Binary	Inches	Inches	Binary	Lbs	Binary	Binary	Integer	Building	Binary	Inches	Inches		Total Happiness		0.84165
Best Value		1	15	12	1	30	1	1	100	Urbauer	1	6	9				
Worst Value		0	1	1	0	300	0	0	1	Parking G	0	10	1				
Actual Value		1	15	12	1	50	1	1	30	Urbauer	1	7	9				
Normalized Metric Happiness		1	1	1	1	0.82	1	1	0.3	1	1	0.75	1				

Figure 7: Concept 1

IoT Pendaflex		Uses Student ID as keycard	Length	Width	Box Locks	Weight	Has wheels	System Secured / Lockable	Number of Boxes	System location	Has wifi access	Height	Input slot width		Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	Device needs to be compatible with Student ID card	1													0	0.1	0
2	Boxes need to be at least 12"x15" area		0.5	0.5											1	0.05	0.05
3	System needs to be FERPA compliant				0.7						0.25		0.05		1	0.3	0.3
4	System needs to be reasonably portable					0.2	0.7			0.1					0.264	0.1	0.0264
5	System needs to be able to be locked to an existing structure						0.1	0.6		0.3					0.9	0.05	0.045
6	System needs to hold homeworks for at least a full class								1						0.3	0.2	0.06
7	Boxes need 24/7 access									0.7	0.3				1	0.1	0.1
8	Boxes should be at least 2" tall								0.1			0.9			0.705	0.05	0.03525
9	TA Slot Needs to fit standard 8 1/2"x11" paper												1		1	0.05	0.05
10															0	0	0
11															0	0	0
12															0	0	0
13															0	0	0
Units		Binary	Inches	Inches	Binary	Lbs	Binary	Binary	Integer	Building	Binary	Inches	Inches		Total Happiness		0.66665
Best Value		1	15	12	1	30	1	1	100	Urbauer	1	6	9				
Worst Value		0	1	1	0	300	0	0	1	Parking G	0	10	1				
Actual Value		0	15	12	1	50	0	1	30	Urbauer	1	7	9				
Normalized Metric Happiness		0	1	1	1	0.82	0	1	0.3	1	1	0.75	1				

Figure 8: Concept 2

IoT Pendaflex		Uses Student ID as keycard	Length	Width	Box Locks	Weight	Has wheels	System Secured / Lockable	Number of Boxes	System location	Has wifi access	Height	Input slot width		Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	Device needs to be compatible with Student ID card	1													1	0.1	0.1
2	Boxes need to be at least 12"x15" area		0.5	0.5											1	0.05	0.05
3	System needs to be FERPA compliant				0.7						0.25		0.05		1	0.3	0.3
4	System needs to be reasonably portable					0.2	0.7			0.1					0.86	0.1	0.086
5	System needs to be able to be locked to an existing structure						0.1	0.6		0.3					1	0.05	0.05
6	System needs to hold homeworks for at least a full class								1						0.3	0.2	0.06
7	Boxes need 24/7 access									0.7	0.3				1	0.1	0.1
8	Boxes should be at least 2" tall								0.1			0.9			0.705	0.05	0.03525
9	TA Slot Needs to fit standard 8 1/2"x11" paper												1		1	0.05	0.05
10															0	0	0
11															0	0	0
12															0	0	0
13															0	0	0
Units		Binary	Inches	Inches	Binary	Lbs	Binary	Binary	Integer	Building	Binary	Inches	Inches		Total Happiness		0.83125
Best Value		1	15	12	1	30	1	1	100	Urbauer	1	6	9				
Worst Value		0	1	1	0	300	0	0	1	Parking G	0	10	1				
Actual Value		1	15	12	1	200	1	1	30	Urbauer	1	7	9				
Normalized Metric Happiness		1	1	1	1	0.3	1	1	0.3	1	1	0.75	1				

Figure 10: Concept 3

IoT Pendaflex		Uses Student ID as keycard	Length	Width	Box Locks	Weight	Has wheels	System Secured / Lockable	Number of Boxes	System location	Has wifi access	Height	Input slot width		Need Happiness	Importance Weight (all entries should add up to 1)	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	Device needs to be compatible with Student ID card	1													0	0.1	0
2	Boxes need to be at least 12"x15" area		0.5	0.5											1	0.05	0.05
3	System needs to be FERPA compliant				0.7						0.25		0.05		0.75	0.3	0.225
4	System needs to be reasonably portable					0.2	0.7			0.1					0.964	0.1	0.0964
5	System needs to be able to be locked to an existing structure						0.1	0.6		0.3					1	0.05	0.05
6	System needs to hold homeworks for at least a full class								1						0.3	0.2	0.06
7	Boxes need 24/7 access									0.7	0.3				0.7	0.1	0.07
8	Boxes should be at least 2" tall								0.1			0.9			0.705	0.05	0.03525
9	TA Slot Needs to fit standard 8 1/2"x11" paper												1		1	0.05	0.05
10															0	0	0
11															0	0	0
12															0	0	0
13															0	0	0
Units		Binary	Inches	Inches	Binary	Lbs	Binary	Binary	Integer	Building	Binary	Inches	Inches		Total Happiness		0.63665
Best Value		1	15	12	1	30	1	1	100	Urbauer	1	6	9				
Worst Value		0	1	1	0	300	0	0	1	Parking G	0	10	1				
Actual Value		0	15	12	1	50	1	1	30	Urbauer	0	7	9				
Normalized Metric Happiness		0	1	1	1	0.82	1	1	0.3	1	0	0.75	1				

Figure 9: Concept 4

3.3.2 Preliminary analysis of each concept's physical feasibility

Concept 1

This concept uses the idea of having the boxes mounted to a rolling cart. The boxes could be expanded depending on the class size. The control CPU can be stored in the cart and Student ID card reader mounted to the boxes for ease of use and access. This design will need the physical boxes, one electronic lock for every box, a card reader, control CPU, and a rolling cart with large casters to be compatible with rolling it through campus. All parts could be purchased and be put together.

Concept 2

This concept uses individual RFID cards and readers for every box. This has the same components as concept 1, except more materials would need to be purchased since every student would need an RFID card and every box would need a card reader.

Concept 3

This concept uses the same idea as concept 1 however the shell would need to be fabricated and the number of boxes would be set and not expandable. Because the system is in a fabricated shell, large handles could be installed for ease of transportation through campus. This concept would be the most difficult to fabricate and assemble.

Concept 4

This concept has no electronic parts and uses mechanical lock and key. This concept would again be on the expensive side since individual keys would need to be purchased and distributed. The benefit of this design is with 24/7 access there are no issues with power or internet outages.

3.3.3 Final summary statement

After interview, initial concept design, and scoring we have selected concept 1 as our optimal design. Concept 1 best fits the most user needs while keeping costs down. This concept also has benefits of ease of assembly and is the most customizable depending on class size. Concept 2 would have all the same benefits of concept 1 however would incur a much greater cost since more operating materials are needed, so this concept was eliminated. Concept 3 was very similar to 1 but loses out due to fabrication, weight, and portability issues. The case would need to be purchased or fabricated as opposed to multiple components assembled. To keep costs down, this concept was also eliminated. Concept 4 had some great benefits, but due to the request to use student ID and the cost of multiple keys being made for each box, this concept was also eliminated. Concept 1 makes the most sense from a user needs, cost of assembly, fabrication, portability, and ease of use standpoint.

User need #3 “The system needs to be fully FERPA compliant” will be our overall performance metric. This need was the biggest emphasis of the user needs interview and is a major component of why the old system is no longer usable.

4 EMBODIMENT AND FABRICATION PLAN

4.1 EMBODIMENT/ASSEMBLY DRAWING

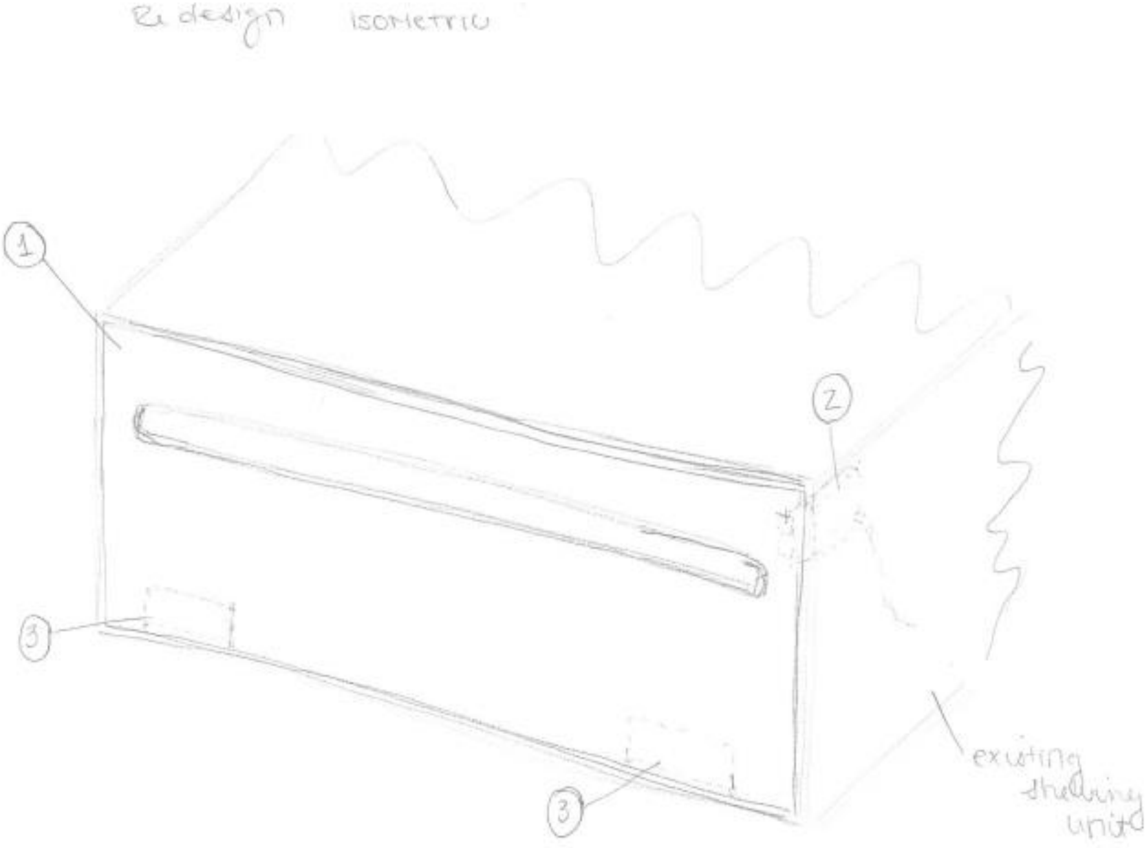


Figure 11: Redesign sketch 1

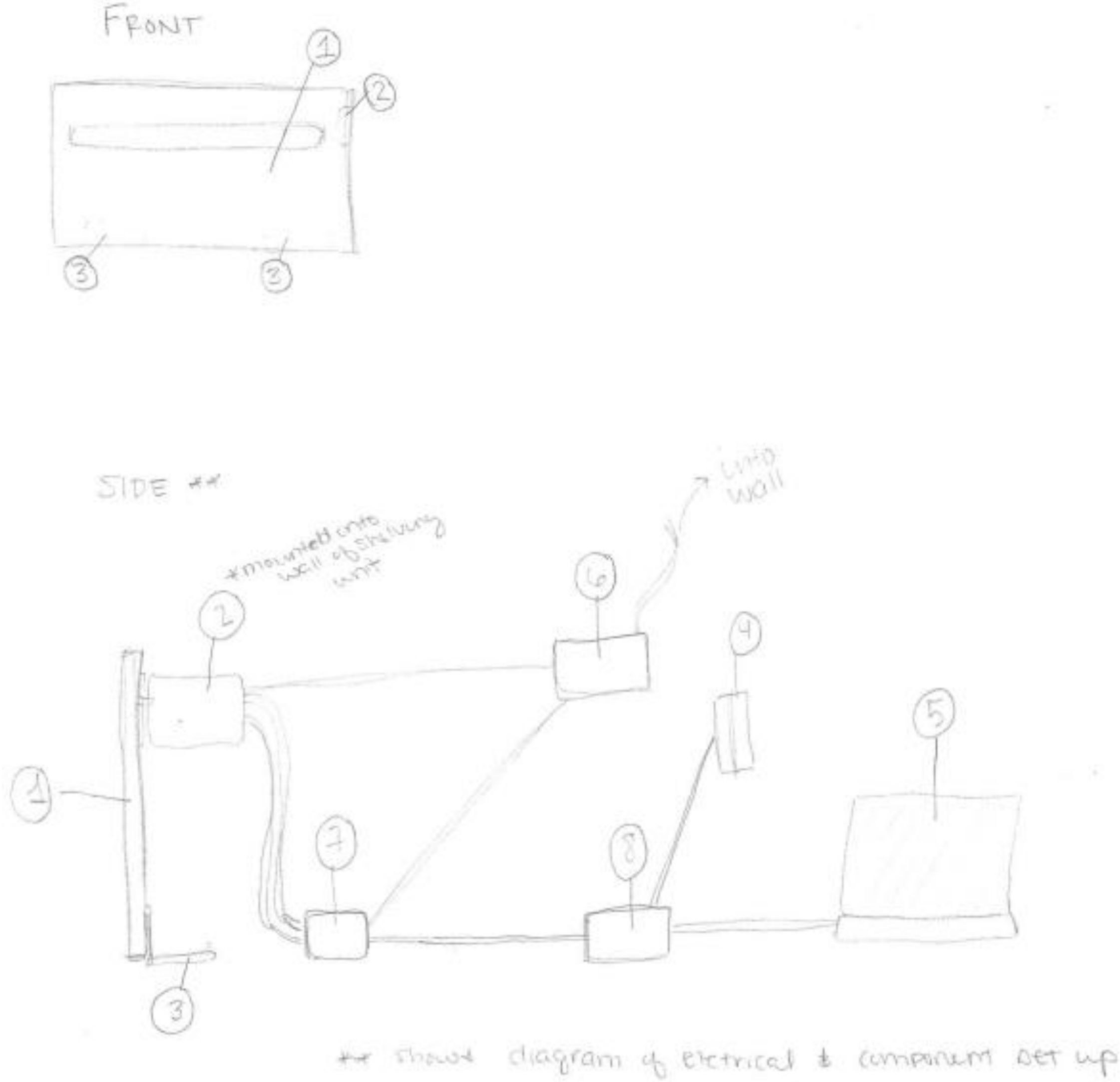


Figure 12: Redesign sketch 2

4.2 PARTS LIST

1.)

- (1) Salsbury Industries 3551ALM Replacement Door/Lock, Aluminum
  - Part No. 3551ALM (Purchased)
  - $34.97 via Amazon.com

2.)

- (1) Atoplee DC 12V 2A Intelligent Electric Door Lock
  - Part No. 17040030 (Purchased)
  - $10.99 via Amazon.com

3.)

- (2) Everbilt 3 ½" x ¼" radius door hinge
  - Part No. 14985 (Purchased)
  - $2.83 ea. via Home Depot

4.)

- (1) MSR90 USB Swipe Magnetic Credit Card Reader
  - Part No. MSR90 (Purchased)
  - $15.99 via Amazon.com

5.)

- (1) Group owned laptop
  - Existing component
  - $0 cost

6.)

- (1) TECOMLIGHT 12V 6A 72W AC DC Power Supply
  - Part No. HLT-1200600C (Purchased)
  - $12.69 via Amazon.com

7.)

- (1) HiLetgo 5V 1 Channel relay module
  - Part No. 3-01-0340 (Purchased)
  - $5.79 via Amazon.com

8.)

- (1) Raspberry Pi 4 Model B
  - Part No. SC0192 (Purchased)
  - $35.00 via MicroCenter

Total Cost: $120.59

Figure 13: Parts list

4.3 DRAFT DETAIL DRAWINGS FOR EACH MANUFACTURED PART

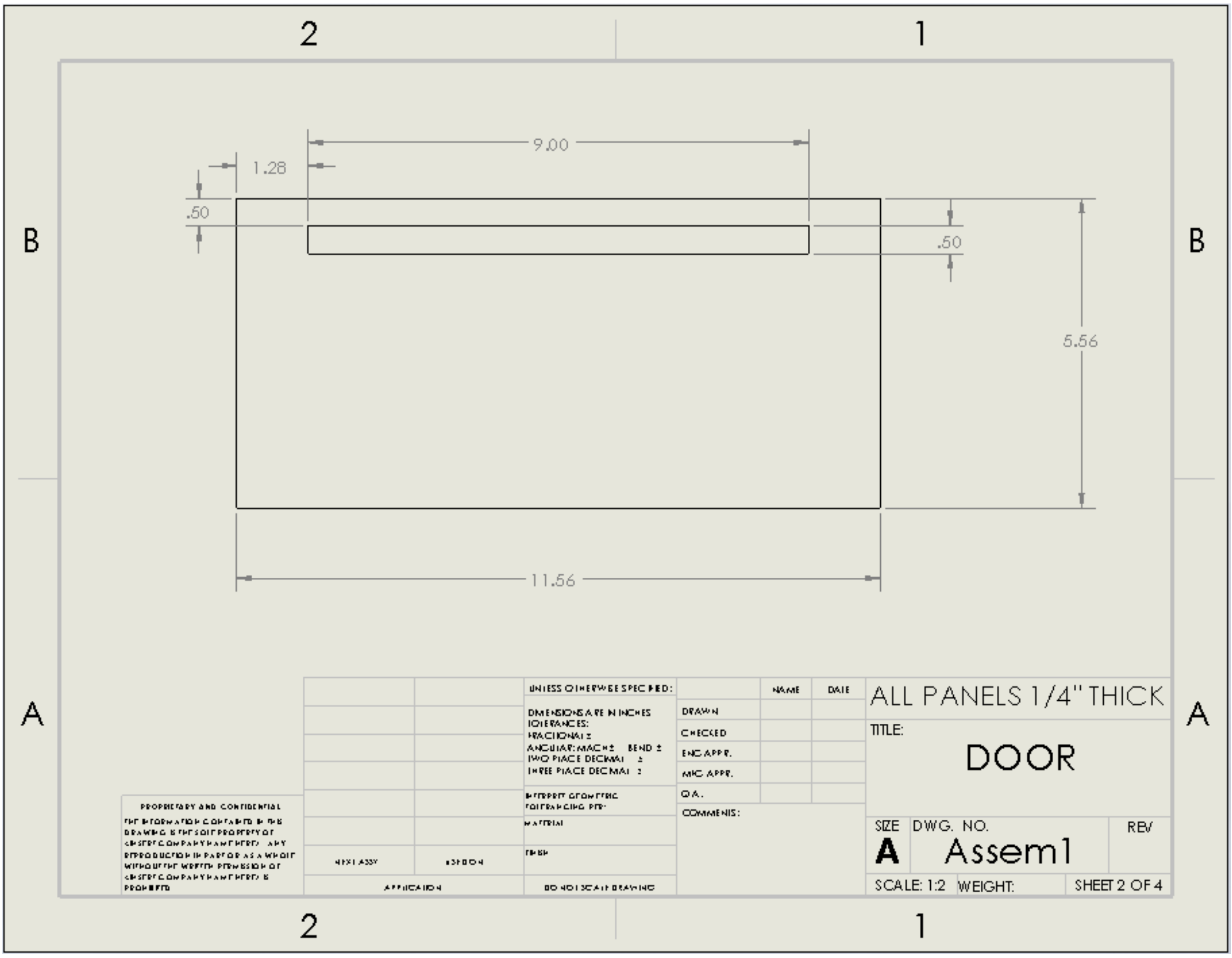


Figure 14: Embodiment drawing of the door

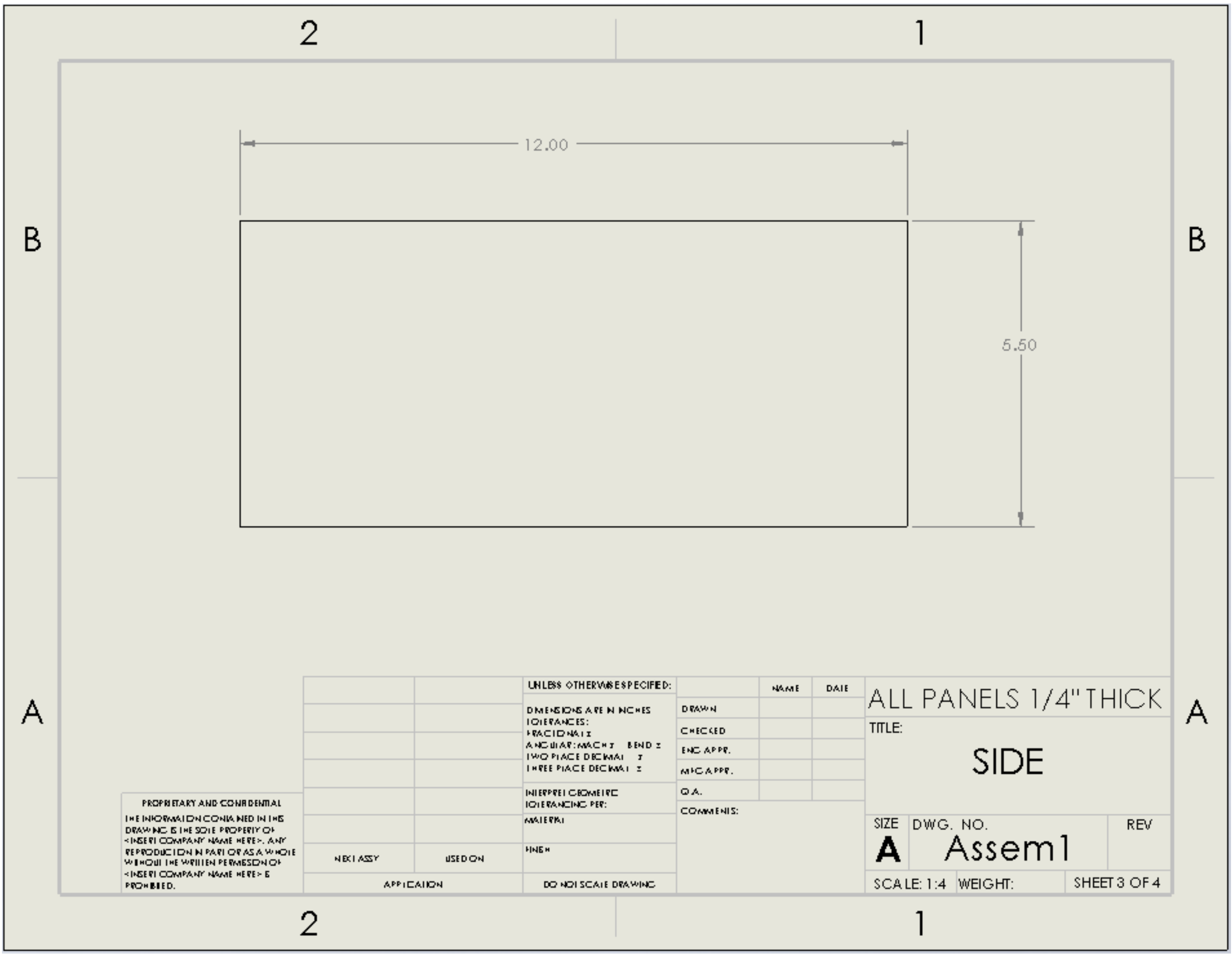


Figure 15: Embodiment drawing of the side

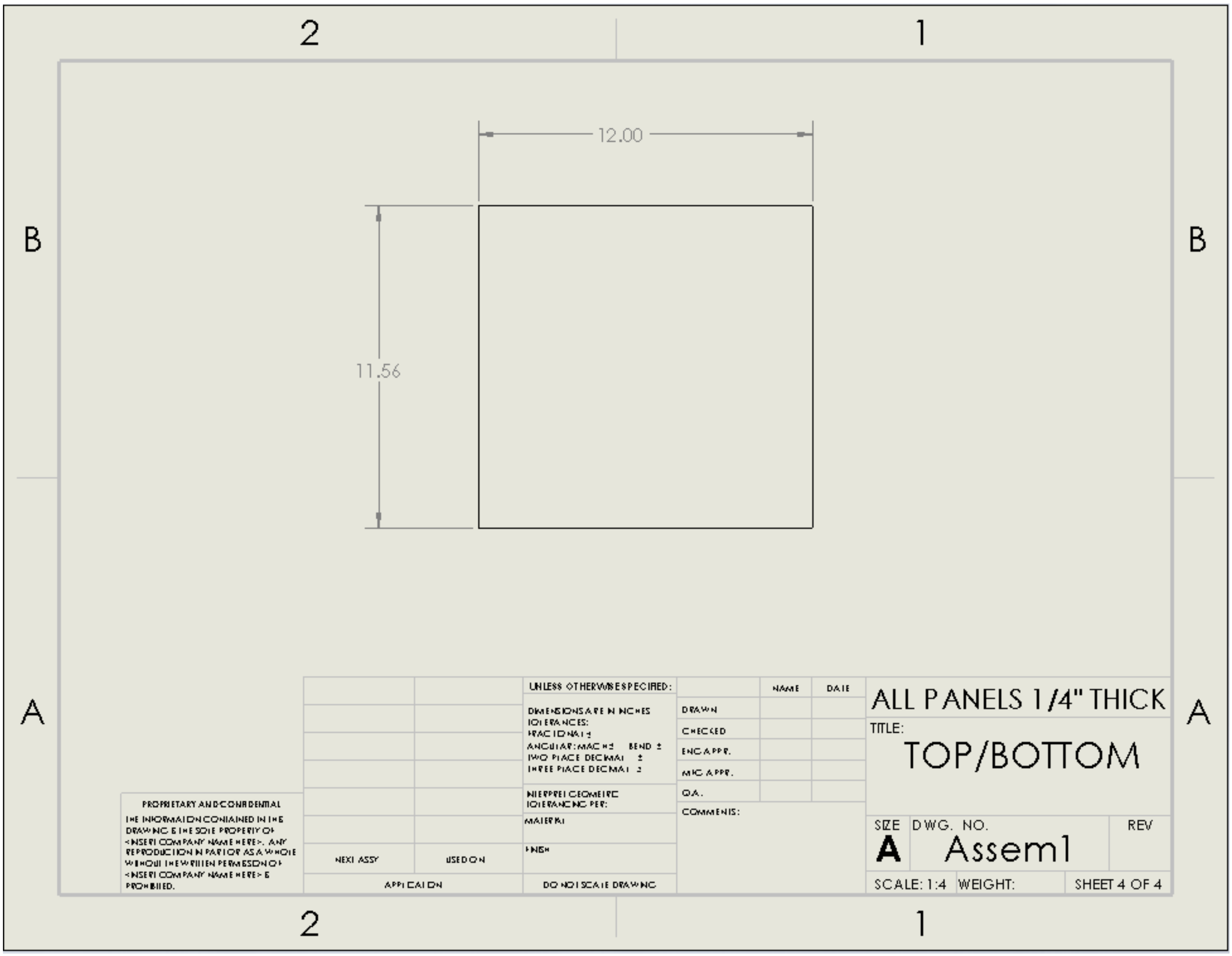


Figure 16: Embodiment drawing of the top/bottom panels

4.4 DESCRIPTION OF THE DESIGN RATIONALE

Description of the design rationale for the choice/size/shape of each part

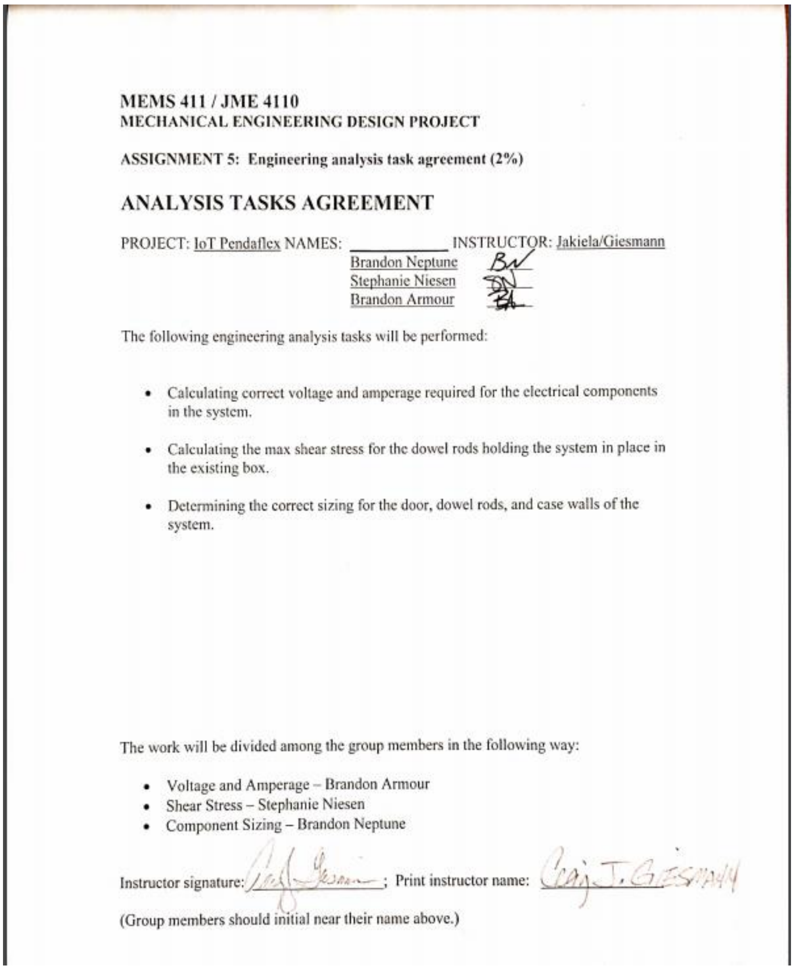
1. This door was chosen due to availability and similar sizes to that of the mailbox. This was the closest door we could find to the needed sizes. It does not have the input slot needed, so will need to be machined/modified. Another discussed option is 3-D printing the exact door needed. This decision will be based on customer needs follow up.
2. The lock was chosen due to 12V compatibility with our Raspberry Pi system. Other factors were price and size. This lock is small enough to fit in the enclosed space.
3. The door hinges were chosen solely on size and price. They need to be small enough to fit in out mail slot. Most cabinet hinges were too large.
4. The card reader was chosen based on USB compatibility with our Raspberry Pi. Other factors for selection were size and price.
5. The group owned laptop was selected due to availability and that no costs were required.
6. The power supply was selected due to needing a 12V supply. This power adapted also has the needed +/- connections.

7. The relay module was selected based on 5V/12V compatibility with our system. Other factors were size and price.
8. The raspberry pi was selected as a control system based on price, size, and compatibility with all needed parts. The raspberry pi will control everything needed in our system.

5 ENGINEERING ANALYSIS

5.1 ENGINEERING ANALYSIS PROPOSAL

5.1.1 Signed engineering analysis contract



MEMS 411 / JME 4110
MECHANICAL ENGINEERING DESIGN PROJECT

ASSIGNMENT 5: Engineering analysis task agreement (2%)

ANALYSIS TASKS AGREEMENT

PROJECT: IoT Pendaflex NAMES: ____________ INSTRUCTOR: Jakiela/Giesmann
Brandon Neptune
Stephanie Niesen
Brandon Armour

The following engineering analysis tasks will be performed:

- Calculating correct voltage and amperage required for the electrical components in the system.
- Calculating the max shear stress for the dowel rods holding the system in place in the existing box.
- Determining the correct sizing for the door, dowel rods, and case walls of the system.

The work will be divided among the group members in the following way:

- Voltage and Amperage – Brandon Armour
- Shear Stress – Stephanie Niesen
- Component Sizing – Brandon Neptune

Instructor signature: ____________; Print instructor name: ____________

(Group members should initial near their name above.)

5.2 ENGINEERING ANALYSIS RESULTS

a. Voltage system
b. Dowel pins
c. Door design

5.2.1 Motivation

a. The correct voltage and current needs to be determined for the electrical components of the system. A power requirement also needs to be calculated. Without proper voltage and current the system will either not work entirely or could overload certain components of the system rendering them useless and creating a safety hazard. A power requirement is also useful because we can determine the yearly operational cost per unit which can be used in marketing and presentation of the product.

b. We need to see if the dowel pins are secure enough for holding the box in the shelf provided. Dowel pins are made of wood.

c. Analyzing the door structure for its ability to keep the contents of the box secure. The purpose of this project is to design a secure space for homework to be returned, the door of this box is the primary source of security for these contents. This is the motivating fact for the analysis of the door. To analyze the door tabulated material properties were used to determine whether or not our designed door is up to the task and use that information to drive iterations of the design.

5.2.2 Summary statement of analysis done

a. Ohm's Law was used in this analysis of P=VI where P is power in watts, V is voltage in volts, and I is current in amps. It was found that the 12V 6A DC power supply would be an acceptable supply for this application.

b. Using the modulus found in CES, we found that the wood dowel pins are sufficient to hold our box into the shelving unit.

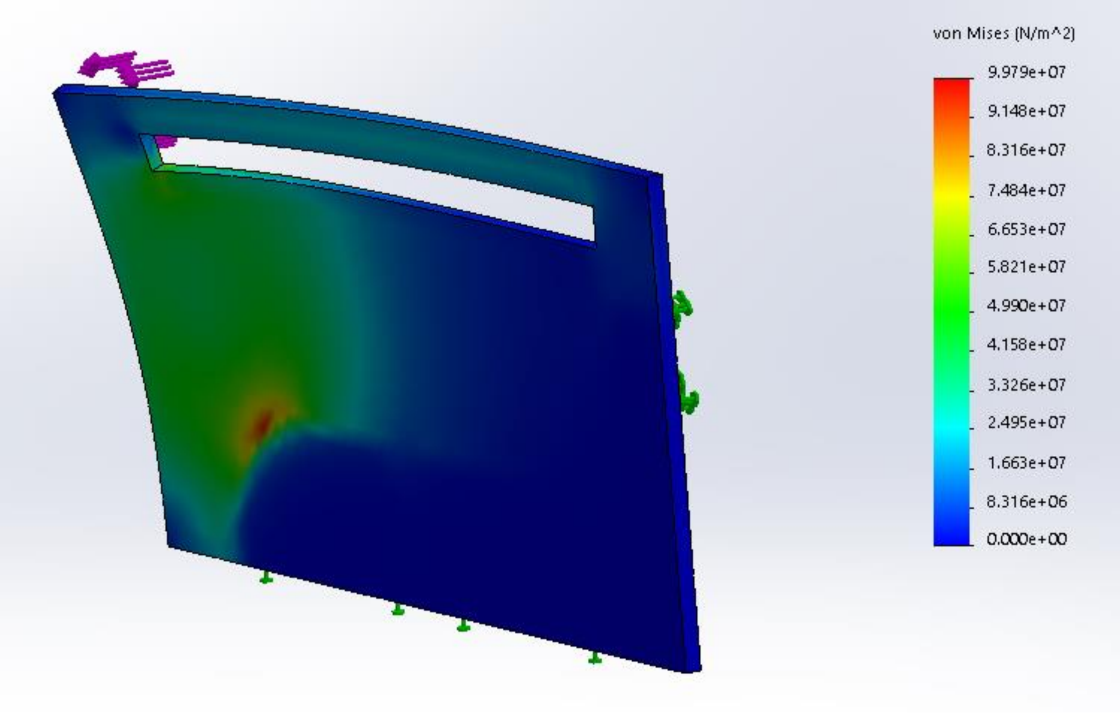
c. 

Figure 17: VonMises stresses front

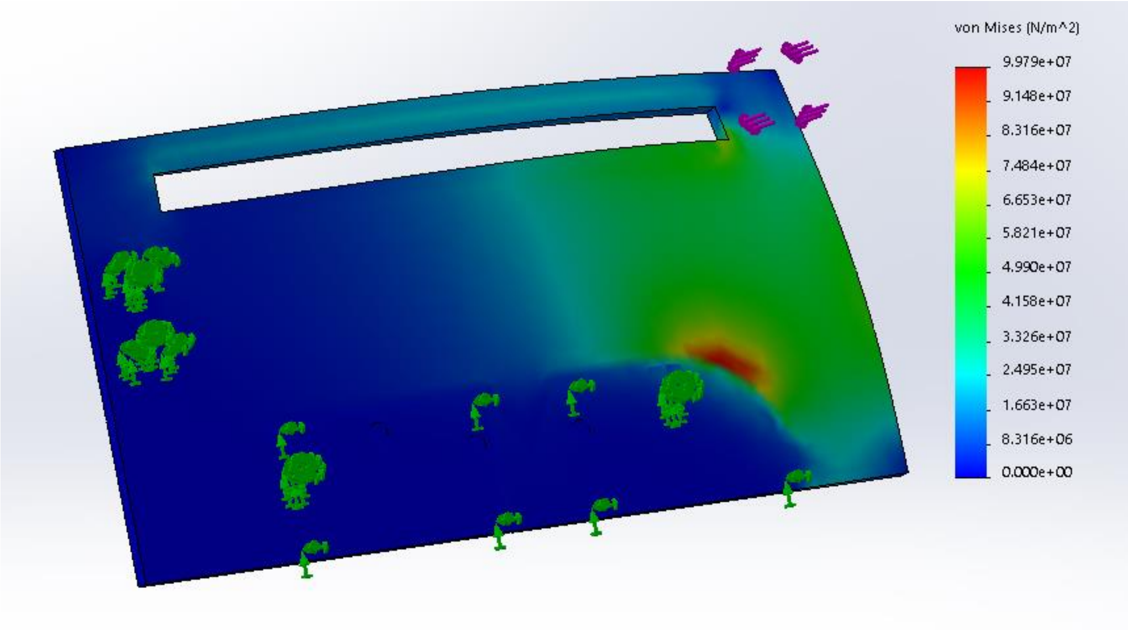


Figure 18: VonMises stresses back

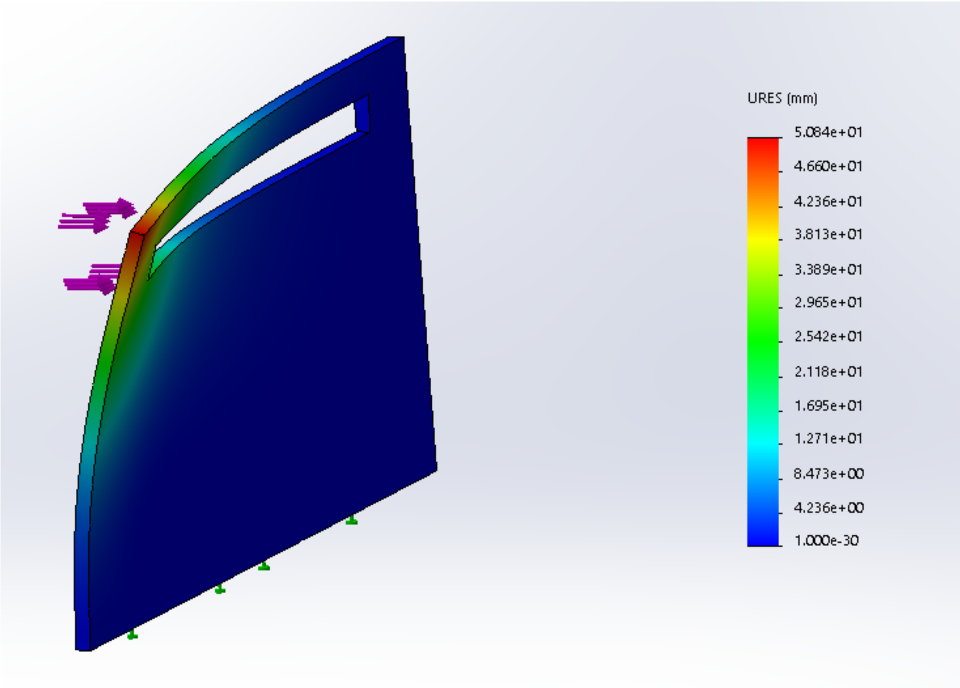


Figure 19: Displacement when pried from the weakest corner.

5.2.3 Methodology

a. Since the system runs on DC voltage and current, we can use Ohm's Law for all calculations. Ohm's law states that a system's voltage multiplied by its current is equal to the power required of the system or P=VI, where P is power in watts, V is voltage in volts, and I is current in amps.

b. Using software available to us, we used the CES software that we learned to use in Material Selection. CES is a great tool for to use for engineers to view material capabilities and what might fit their requirements best.

c. This analysis was done with Solidworks Simulation to compute the stresses within the door under a large load associated with a break-in scenario. The green arrows on the door indicate the fixed points of the door when closed and locked, hinges at the bottom of the door and the locking shackle. The purple arrows represent a load experienced if someone were attempting to open the door without unlocking it, by prying it open. The loading constraints were chosen based off the worst case scenario so the prying load was placed in the corner least supported by the fixed mounting points, in the upper left corner.

5.2.4 Results

a. Since our AC power input will be a standard 120V AC our power transformer will convert to a 12V, 6A max DC source. A DC powered unit will on draw the current it needs from the source. Our lock requires 12 V, 2A DC and our adapter will supply 12V 6A max DC. Since the power supply will not be operating near its maximum it will not have to work as hard to handle the smaller load. It will run cooler and more stable. Using Ohm's Law, we can easily see that the power draw for this unit is 24W. The yearly operation cost is based on a couple of estimates and assumptions. The first being that the unit will be in operation for approximately 1 hour per week. Second, we are using the average residential kWh rate for St. Louis of $0.0969/kWh. This unit will use 0.024kWh per week at a yearly total of $0.12 in energy costs for operational use.

b. Wood:

Young's Modulus 6-20 GPa

Yield Strength (elastic limit) 30-70 Mpa

Tensile Strength 60-100 MPa

Density 600 – 800 kg/m^3

$$\sigma = \sigma_y \, sin^2\theta$$

$$\sigma = 20 \times 10^9 \cdot sin^2 90° = 20 \, Gpa$$

$$\tau = \frac{1}{2}\sigma_y \, sin2\theta$$

$$\tau = \frac{1}{2} \cdot 20 \times 10^9 \cdot \sin 2(90) = 0$$

The results are as expected. Dowel pins are used in shelving or furniture units that hold significant weight. The only drawback is that they will not be glued into the shelves, so that will decrease their stability a tiny bit. The dowels will be a tight fit into the holes provided; the snug fit shall help secure the box in place.

c. According to the simulation the door experienced a maximum displacement of the upper corner of 1.9" under a 100 pound load. This amount of deflection makes sense for this large loading. I believe this is an acceptable amount of deflection as this amount of deflection may be just enough to gain access through a locked door.

5.2.5 Significance

a. The most significant influence in the design and prototype was using the voltage and current needs to find a compatible power supply for the system.
b. We picked this material due to cost and availability. The dowels will fit nicely into the prefabricated holes in the shelving unit available. We believe, with the data found, that the wood dowel joints will withstand daily use; thus making the unit secure. The chosen small, wood dowels will be used in the final prototype.
c. These results support the validity of the current design, so no changes are strictly necessary. However newer designs may be considered based on the stress concentration locations in the simulation.

6 RISK ASSESSMENT

6.1 RISK IDENTIFICATION

- Power overloading
- The lock breaking
- The student not having their ID to access the box.
- The box being exposed to water or liquid spillage.

6.2 RISK ANALYSIS

Structural stability of our box.	Risk: Medium	Due to the nature of plywood being thin and soft, the structure could be compromised either in the wood or where the pieces connect.	We have treated the box with care and secure a few main pieces the best we could with the materials available.
System running too much power into the lock	Risk: Medium	Too much power can fry the lock electrical components.	Ensure that wires are connected correctly to the raspberry pi
Hinges coming unglued.	Risk: Low	The locking mechanism has quite a bit of force behind it.	Will demo on the table, in order to help cushion the door opening.
Student not having their ID	Risk: Medium	The student will not being able to access their homework and tests.	Student can acquire a new ID from the administration office. The code can be reprogrammed with the new ID, if their strip numbers are different from the original.

6.3 RISK PRIORITIZATION

Our Group had to prioritize budget over almost anything else. Within this constraint, and with delays on printing a door, we decided on plywood for the main body material. This way we were able to concentrate on the electrical components used for the lock, raspberry pi, and programming. Since the concept or our design can be expanded with some further coding, this part was prioritized over the overall structure.

7 CODES AND STANDARDS

7.1 IDENTIFICATION

FERPA or Federal Educational Rights and Privacy Act is a US Federal law that sets restrictions for access student's educational information and records. This act requires written authorization to disclose a student's grades to anyone other than the student directly. This law applies to all schools that receive funds from the U.S. Department of Education.

"Family Educational Rights and Privacy Act (FERPA)." *Home*, US Department of Education (ED), 1 Mar. 2018, www2.ed.gov/policy/gen/guid/fpco/ferpa/index.html.

7.2 JUSTIFICATION

FERPA was the inspiration behind the idea of this project. The original pendaflexes were removed due to non-compliance with FERPA. By creating a new system completely compliant with this law, professors will have a new way to return homework in a timely fashion without using valuable class time. The new system must be compliant with all standards of FERPA law.

7.3 DESIGN CONSTRAINTS

7.3.1 Functional

The box must

- Allow specific students, TA's, and professors access into the box to return/pick up graded work
- Be reprogrammable
- Fail-safe to locked if power is lost
- Allow homework drop off without being opened
- Be able to be secured to existing mail slot arrangement and not permanently deform or mar the slots

7.3.2 Timing

- Allow 24 hour access to be returned/picked up to students and faculty

7.3.3 Economic

- Be affordable enough to be feasible if scaled up to large quantities

7.3.4 Legal

- Meet FERPA regulations for security
- Conceal all documents contained

7.4 SIGNIFICANCE

The input slot was made shorter on the fabrication plan as opposed the initial embodiment drawing. The slot will be tall enough for a few papers to be input, but not much more. This will allow for privacy and other users will not be able to see directly in to the box. The FERPA law was the direct inspiration behind using a student ID, card reader, and electromagnetic lock. These parts were all included in the initial embodiment and fabrication plan. Lastly, the securing of the box was a design modification made for FERPA compliancy. Originally, our design was to put a door on an existing system, but with building an entire case, we can secure the system to an existing mailbox using the side holes of the mailbox and dowel rods to secure it.

8 WORKING PROTOTYPE

8.1 PROTOTYPE PHOTOS

At least two digital photographs showing the prototype

Figure 20: Interior of the box

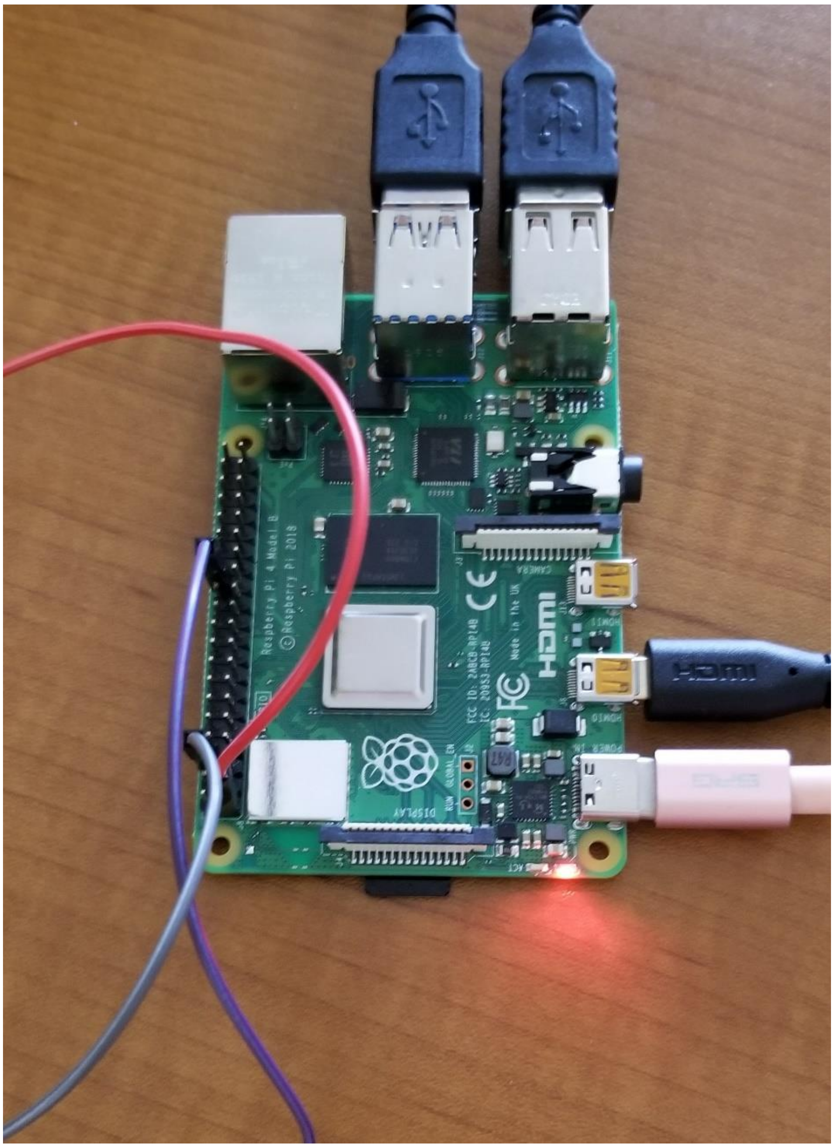


Figure 21: RaspberryPi

8.2 WORKING PROTOTYPE VIDEO

HTTPS://WWW.YOUTUBE.COM/WATCH?V=XBNS-NMAOMW&FEATURE=YOUTU.BE

8.3 PROTOTYPE COMPONENTS

Figure 23: The card reader reads the student ID number off of the student ID

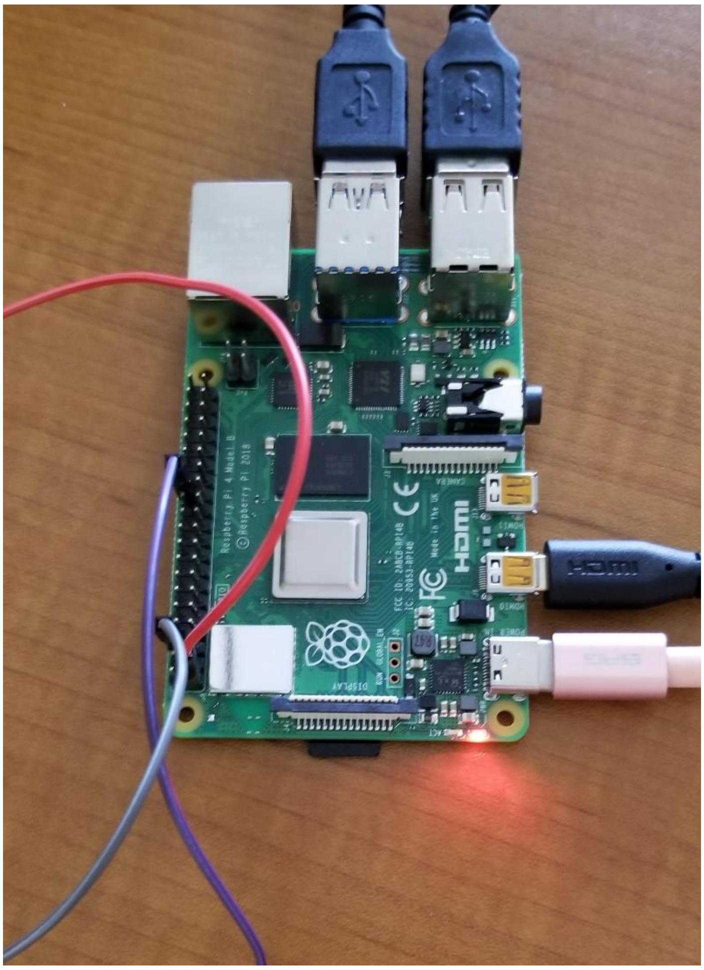


Figure 24: The RaspberryPi reads the ID code. If the ID is recognized and authorized to access the box, the ‘Pi sends a 5V signal to the relay.

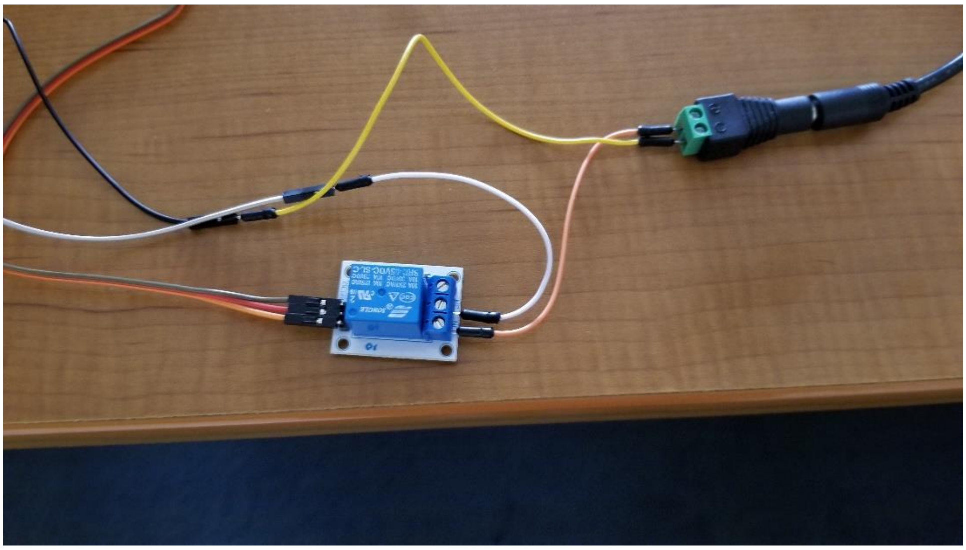


Figure 25: When the relay receives the signal, it closes the circuit to the lock.

Figure 26: The lock releases the door when it receives the signal from the relay.

9 DESIGN DOCUMENTATION

9.1 FINAL DRAWINGS AND DOCUMENTATION

9.1.1 Engineering Drawings

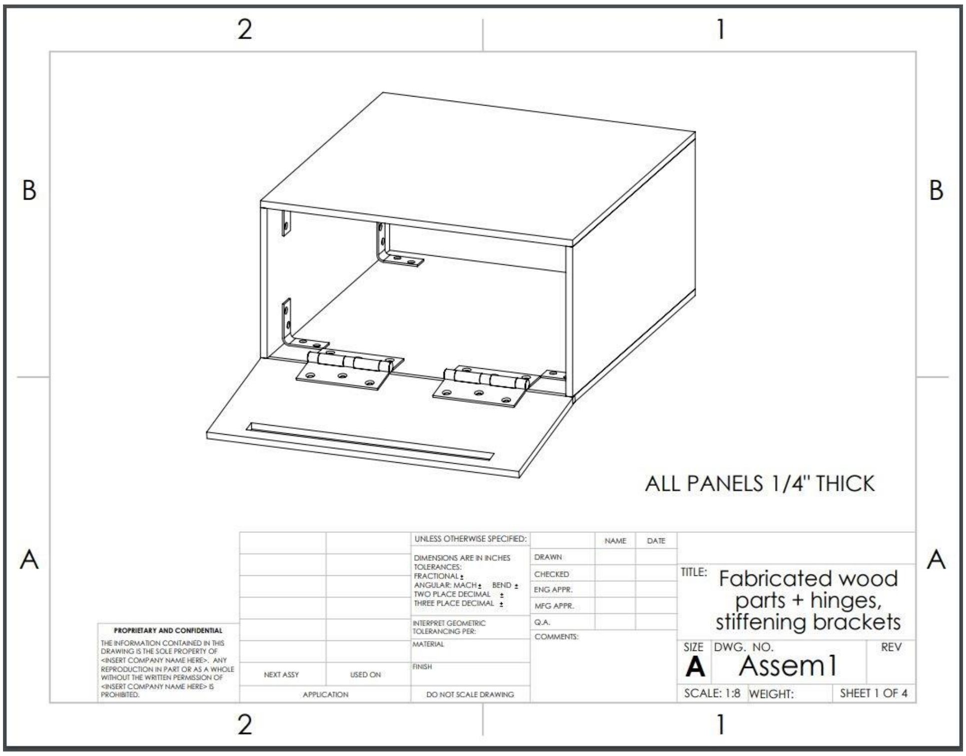


Figure 27: Full assembly of box

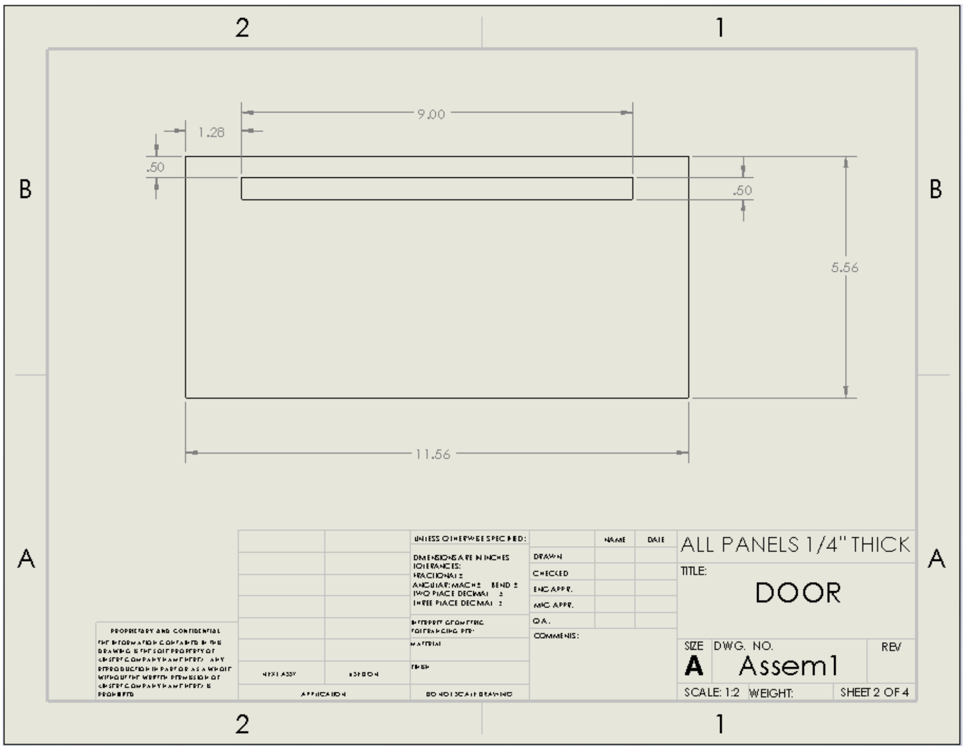


Figure 28: Door dimensions

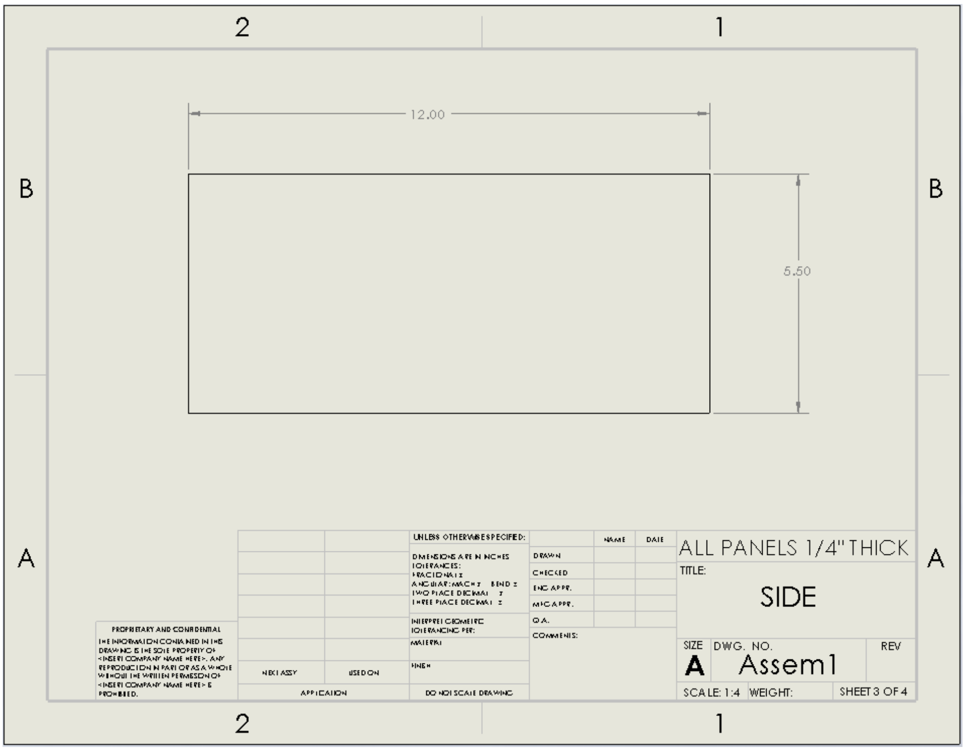


Figure 29: Side panels

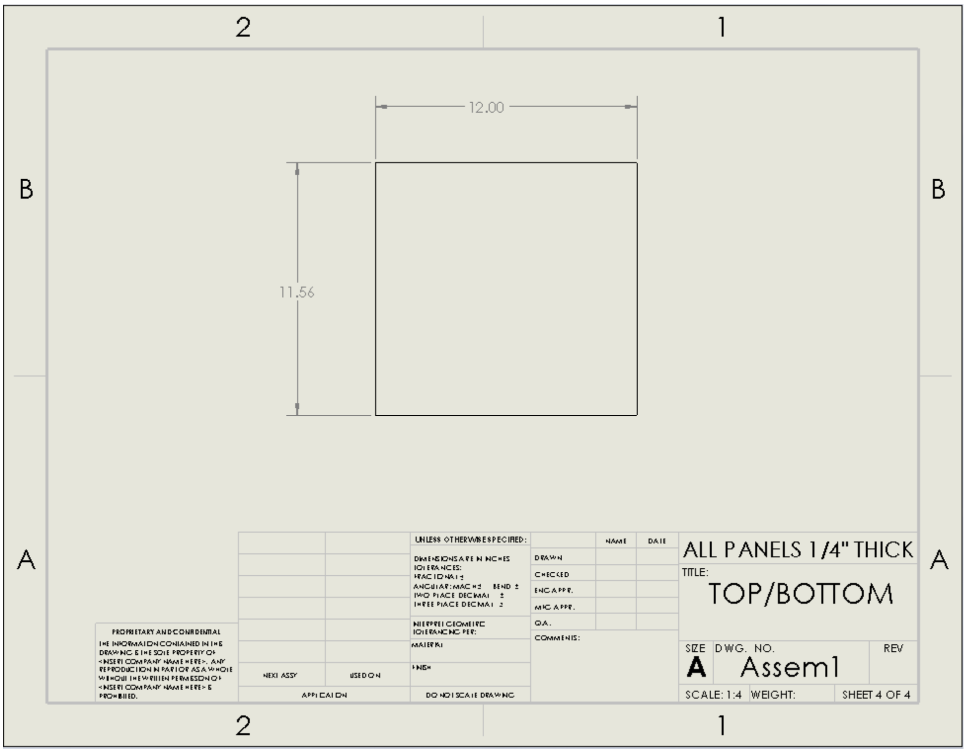


Figure 30: Top and bottom panels

9.1.2 Sourcing instructions

1. 2’ x 4’ x 0.25” medium density fiberboard
    - Part No. 099167702186 (purchased)
    - $6.53 via Home Depot
    - The fiberboard was cut into sections for the walls and door of the casing.
2. Atoplee DC 12V 2A Intelligent Electric Door Lock
    - Part No. 17040030 (Purchased)
    - $10.99 via Amazon.com
    - The door lock closes and secures the door of the system.
3. 3.5” radius door hinge (2)
    - Part No. 030699149827 (Purchased)
    - $5.66 via Home Depot
    - The door hinges connect the door to the box casing and allow for the door to open on an axis in a rotational motion.
4. MSR90 USB Swipe Magnetic Credit Card Reader
    - Part No. MSR90 (Purchased)
    - $15.99 via Amazon.com
    - The card reader takes the input from the student ID and sends this data to the Raspberry Pi.
5. TECOMLIGHT 12V 6A 72W AC DC Power Supply
    - Part No. HLT-1200600C (Purchased)
    - $12.69 via Amazon.com
    - The power supply sends 12V 6A max electric signal to the lock to allow for the lock to open.
6. Velleman 5V Relay Module
    - Part No. 265132 (Purchased)
    - $4.99 via Micro Center
    - The relay module receives 5V signal from the raspberry pi and opens the circuit for the 12V power supply to send signal to the lock.
7. Raspberry Pi 4 Model B
    - Part No. SC0192 (Purchased)
    - $35.00 via Micro Center
    - The raspberry pi is the control board for the electronics. It was pre-loaded with Noobs OS and programmed using python.
8. 1 ½” L Brackets (4 pack) (2)
    - Part No. 809447 (Purchased)
    - $5.36 via Lowe’s
    - The L brackets were used to reinforce the stability of the wooden case.
9. Gorilla Gel Super Glue
    - Part No. 670032 (Purchased)
    - $5.98 via Lowe’s
    - The super glue was used to assemble the boards of the case, mount the brackets to the door and case, and also mount the lock and shackle to the case and door respectively.
10. M to M and F to F electrical wires
    - Pre-owned component

    - A bulk package of these wires are readily available for around $5.
    - These wires were used to connect the GPIO pins on the raspberry pi and relay module, power supply, and lock.
11. USB Keyboard
    - Pre-owned component
    - This keyboard is easily available for $5-10.
    - The keyboard was used as input for the raspberry pi for programming and operation.
12. USB Mouse
    - Pre-owned component
    - This mouse is available for under $5.
    - The mouse was used for control of the raspberry pi in programming and operation.
13. Mini HDMI to HDMI adapter
    - Pre-owned component
    - This adapter is available for under $5.
    - The adapter was used to take the mini HDMI output from the raspberry pi to a standard HDMI input for the computer monitor used.
14. Samsung 9V 1.67A power supply
    - Pre-owned component
    - This power supply is available for around $10.
    - The Samsung power supply was used to power the raspberry pi.
15. Samsung computer monitor
    - Pre-owned component
    - A computer monitor can be purchased in the $50-100 range.
    - The monitor was used in operation and programming of the raspberry pi.

TOTAL COST = $103.19

10 TEARDOWN

There is no teardown needed for our project. One of the members of the group is keeping the prototype.

11 APPENDIX A - PARTS LIST

1.)

- (1) Salsbury Industries 3551ALM Replacement Door/Lock, Aluminum
  - Part No. 3551ALM (Purchased)
  - $34.97 via Amazon.com

2.)

- (1) Atoplee DC 12V 2A Intelligent Electric Door Lock
  - Part No. 17040030 (Purchased)
  - $10.99 via Amazon.com

3.)

- (2) Everbilt 3 ½" x ¼" radius door hinge
  - Part No. 14985 (Purchased)
  - $2.83 ea. via Home Depot

4.)

- (1) MSR90 USB Swipe Magnetic Credit Card Reader
  - Part No. MSR90 (Purchased)
  - $15.99 via Amazon.com

5.)

- (1) Group owned laptop
  - Existing component
  - $0 cost

6.)

- (1) TECOMLIGHT 12V 6A 72W AC DC Power Supply
  - Part No. HLT-1200600C (Purchased)
  - $12.69 via Amazon.com

7.)

- (1) HiLetgo 5V 1 Channel relay module
  - Part No. 3-01-0340 (Purchased)
  - $5.79 via Amazon.com

8.)

- (1) Raspberry Pi 4 Model B
  - Part No. SC0192 (Purchased)
  - $35.00 via MicroCenter

Total Cost: $120.59

12 APPENDIX B - BILL OF MATERIALS

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TOTAL COST = $103.19

13 APPENDIX C – COMPLETE LIST OF ENGINEERING DRAWINGS

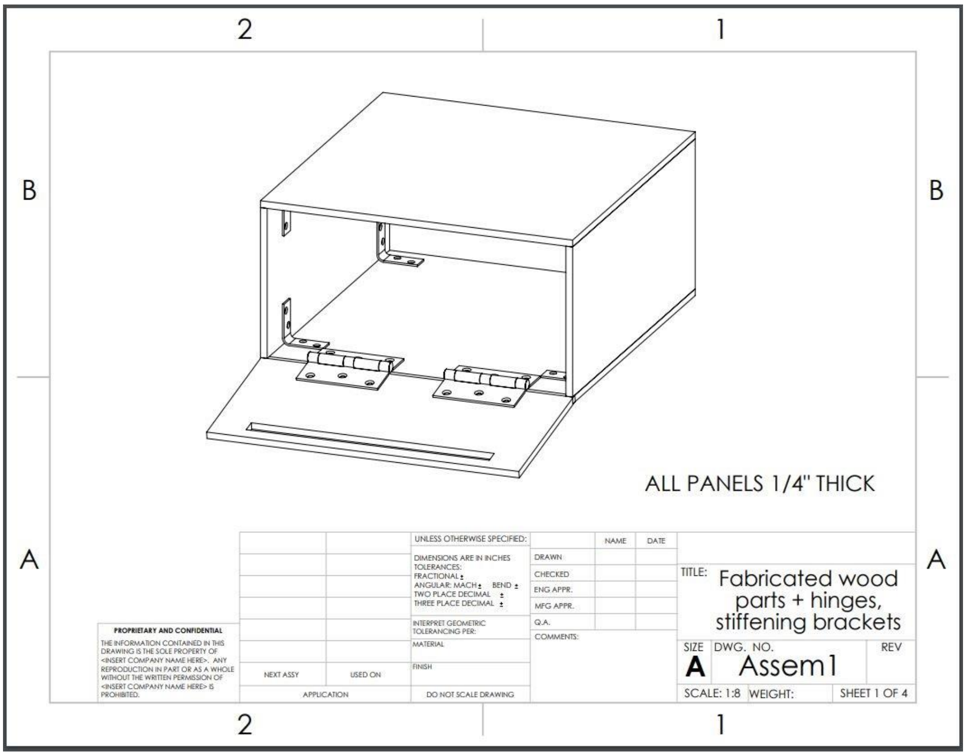

Figure 13.1: entire assembly

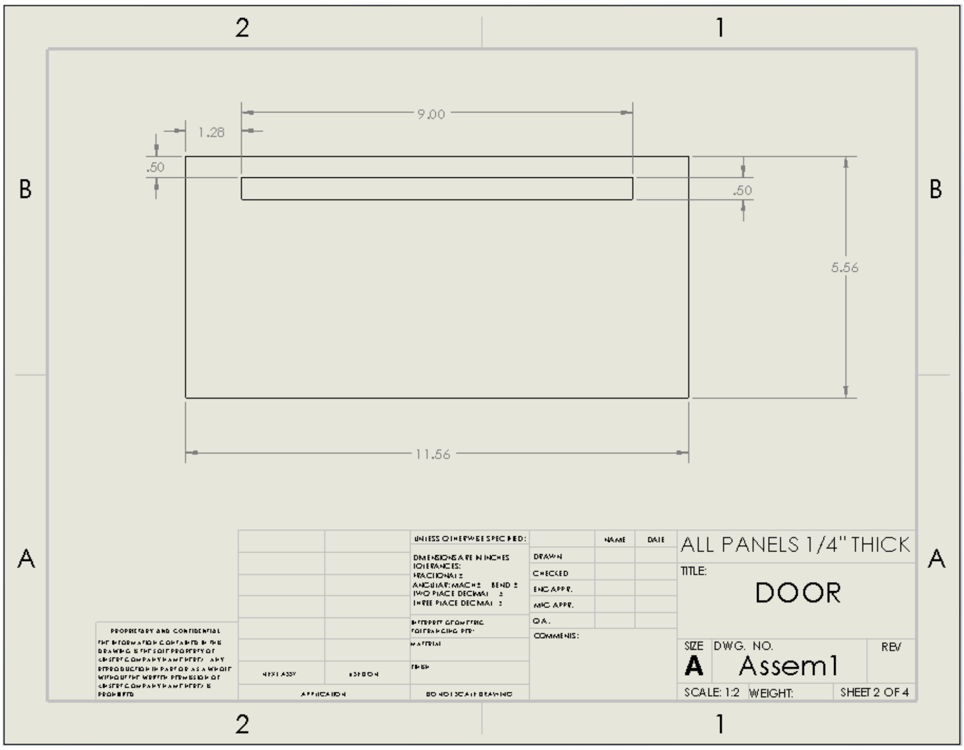

Figure 13.2: Drawing of the door

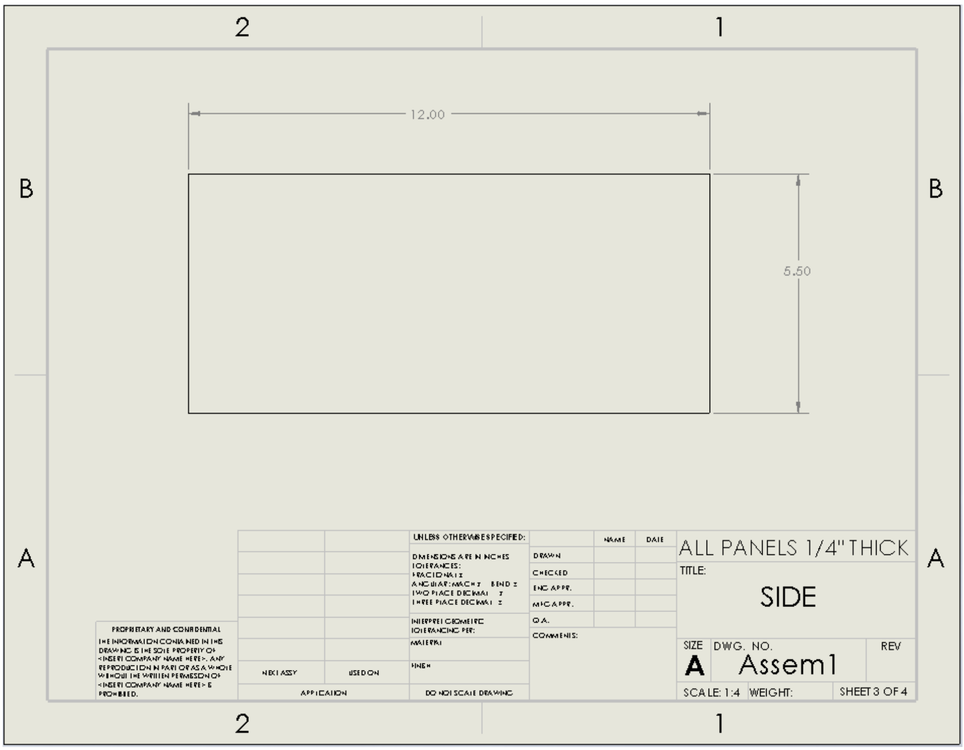

Figure 13.3: Drawing of the sides of the prototype.

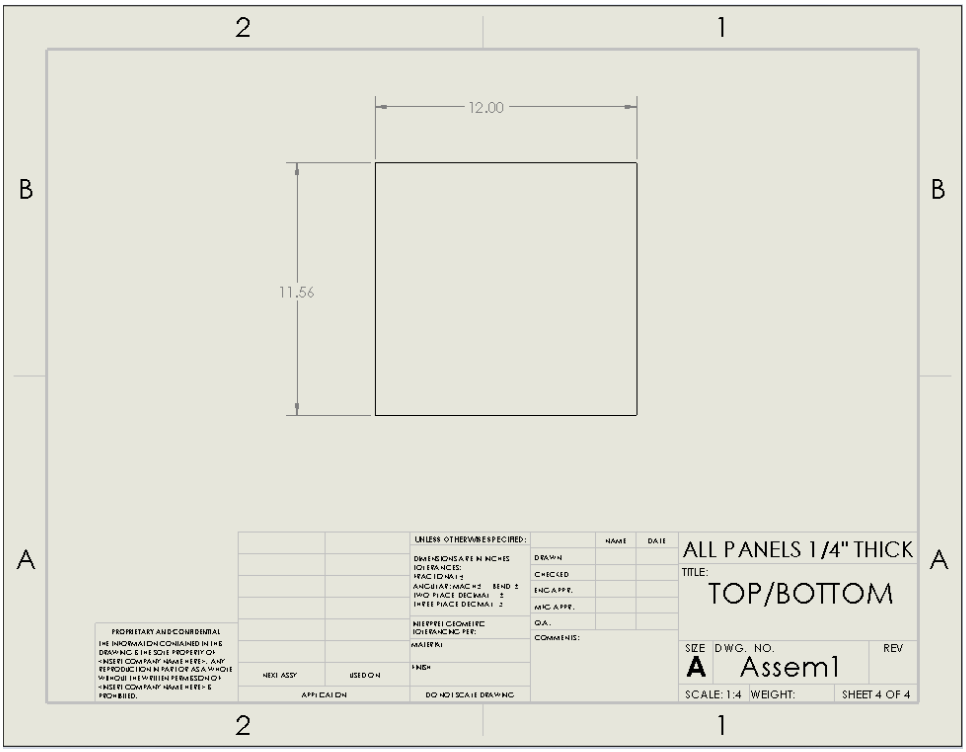

Figure 13.4: Drawing of the top & bottom of the design.