SMART DUMPSTERS

Team 24

Team Members:

JooYong Chung (jdchung2@illinois.edu)
Yisi Liu (yisi2@illinois.edu)
QiHang Zhao (qihang2@illinois.edu)

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1 Introduction

1.1 Problem and Solution Overview

Garbage dumpsters have enabled humans with a better life by allowing us to place trash outside of our houses. Due to their convenience, they have become an integral part of people's daily lives. However, despite the comfort that these big dumpsters have given, big issues associated with conventional use of these dumpsters still exist. These issues include garbage dumpsters overflowing due to people stacking the garbage past its limit, non-residents using the dumpsters without paying any service fees, and the inconvenience of using heavy lids to throw out trash.

Smart Dumpsters address all these problems that come with the inconvenient uses of regular dumpsters. First, by installing a sensor that detects the fullness of a dumpster enables an automatic locking mechanism designed to lock the dumpster when it is full, and it will let the residents of the dumpster know that they should use another dumpster to throw away their garbage. Second, the locking and unlocking mechanism of the dumpster will give only the residents who paid for these services the access to the use of these dumpsters. Finally, the keycards that will unlock and automatically open the lid will enable any resident to use the smart dumpster conveniently.

1.2 Background

Currently, there has been a big shift in technology for automatic tools. The doors that schools use have become electronic to allow people who have disabilities to use them with more convenience. It also allows access through keycards that enable people to lock and unlock the doors (this can be seen in our very own ECE building). The garbage cans we use in our everyday life have become automatic so that it can open with a sensor detecting hand motions.

Likewise, the creation of a smart dumpster will provide a new convenience that had not existed in a market. First, it will allow people with disabilities the independence in throwing out the garbage. This is also true not only for the people with disabilities, but for the people who aren't tall enough, such as kids, and not strong enough, such as elderly people, to throw garbage with more ease. Afterall, the lids for these garbage dumpsters are extremely heavy. Second, the lock and unlock mechanism of the dumpster contributes an extra level of assurance to people who paid for the service and not worry much about the potential overflow of the garbage dumpsters. This will also eliminate the necessity of picking up the dumpster companies to not pick up the overflow of the garbage that is around the dumpsters, and easily clean them. Lastly, the app that will notify the residents of which dumpsters are full will let them know when and where they should throw out the garbage.

1.3 Visual Aid

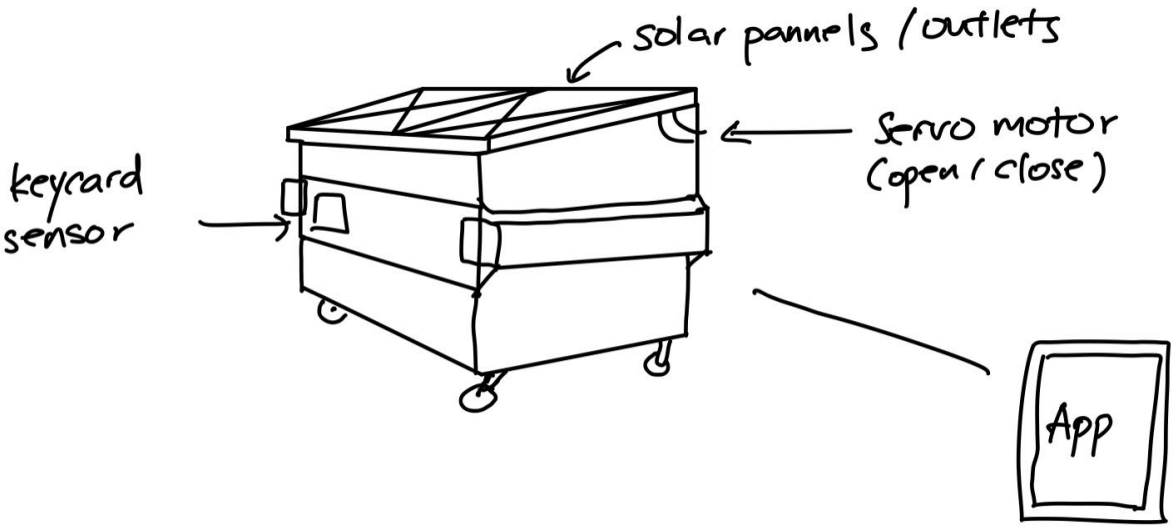

Fig. 1. Outside view sketch

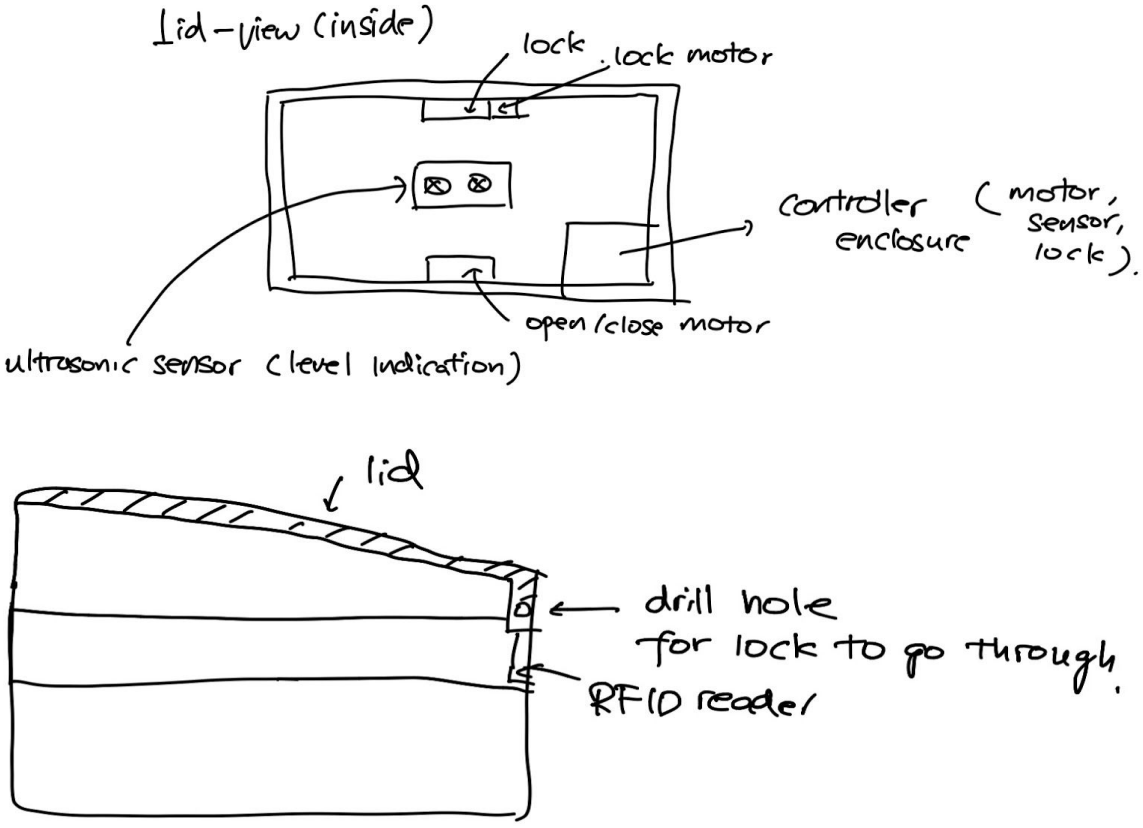

Fig. 2. Top view and side view sketch

The visual aids for this project, shown in both Fig. 1 and Fig. 2, give a rough idea about how the appearance of the dumpster will look like. It will consist of a solar panel top, insulation controller enclosure which will contain all the microcontrollers for the servos and the sensors, an ultrasonic sensor that will sit in the middle on the inside of the lid, and a RFID reader functions as the keycard sensor will sit on the outside for easy access.

1.4 High-level requirements list

1. The sensor that informs when the dumpster is full will operate under an input of 5V. After it receives the bounced back signal from the garbage, this will notify when the dumpster will be locked and notify the app to update the dumpsters as “full” through the wireless wifi module by a 5V voltage.

2. The microcontroller that will open the dumpster’s lid by triggering the input of 12V to the solenoid lock, which will unlock itself, upon the correct UID readings from the RFID reader and S50 card. It will also trigger the automatic opening of the dumpster’s lid for 30 seconds.

3. Solar powered battery which will be charged at 6V by the solar panels needs to be able to provide 5V output for the microcontroller, the servos, and the ultrasonic sensor, and provide 3.3V output for the RFID reader. The battery will also need to be able to supply power to the system for at least 12 hours at consistent 5V without being charged by the solar panel.

2 Design

The project requires four sections for a successful operation: a power unit, a lock and unlock unit, a message unit, and a mobile terminal unit as shown in Fig 3. The power supply makes sure that the entire system can work reliably and continuously all day and night with the proper 5V for the PCB boards, servos, and the ultrasonic sensors, and the battery pack which is charged by the solar panel will output a 3.7 to 4.2V through different converters and regulators to provide those power. The microcontroller chip, ATmega328P, will output the control signals for the entire system. The lock and unlock unit is used to control the opening and closing of the dumpster top cover. The top cover can be opened and closed by the motor driven by a servo attached to the lid of the dumpster and it will open automatically after the dumpster is unlocked. The message unit, which is installed on the inside of the top cover of the dumpster, works for detecting and transmitting the fullness of dumpsters. The mobile terminal unit is used to receive signals from the wireless transmitter to remind users of the availability of all dumpsters.

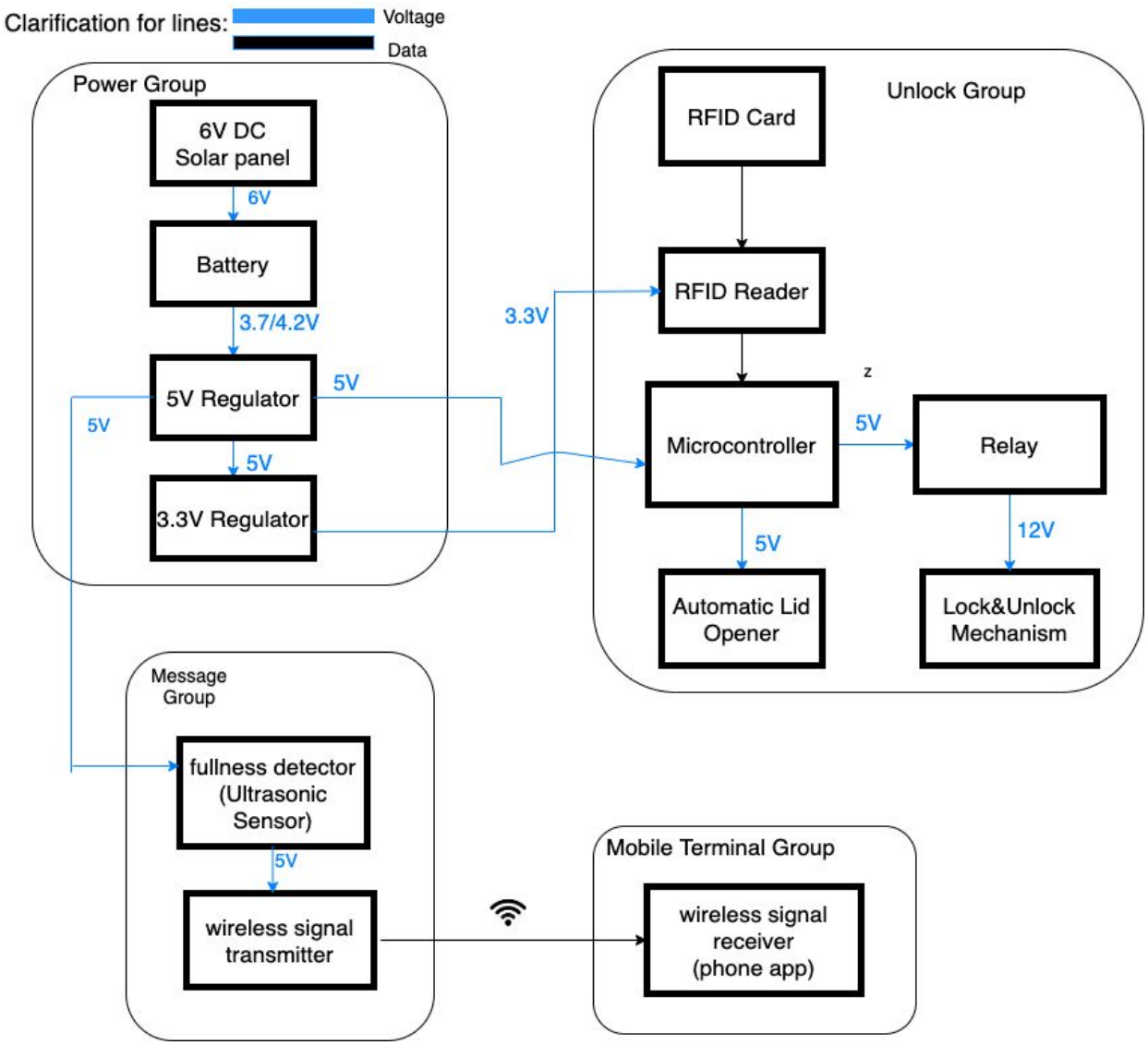

Fig 3. Block Diagram of the smart dumpster

2.1 Power Group

The power supply for this project can be divided into four general parts: a solar panel that is located on top of the lid of the dumpster which will provide a maximum of 6V at 930mA, a charging module which takes the output of the solar panel and converts the voltage accordingly to charge up 3.7/4.2V the battery pack which is rated at 6600mh, and a regulator which will boost the battery output voltage to 5V for powering up the PCB board. A separate voltage regulator will be built on board to step the 5V down to 3.3V for RFID reader. There's an additional relay module used with the RFID reader to operate the lock. It takes an input of 5V and converts it to 12V signal to unlock the lock.

2.1.1 Solar Panel

The solar panel will be connected to the batteries through a charging module to charge up the battery pack. A charging module is used here to prevent overcharging the battery as well as step down the output voltage from the solar panel to the appropriate voltage for charging the battery. For this project, a 6V 6W solar panel will be used to provide a maximum of 930mA current input for charging the battery. The open circuit voltage provided for this solar panel is 7.7V and the close circuit current is 990mA. Since this solar panel will be mounted on top of the lid exposed in the environment, the waterproof ability it provides is necessary as well. Fig.4 shows a technical drawing and some of the important features of the solar panel.

Requirement	Verification
- Outputs a maximum of 930-990mA at 6-7.7V in the sunlight	- Expose the solar panels under the sun - Measure the open-circuit voltage with a voltmeter, ensuring that it is below 7.7V - Place a large resistive load and measure the voltage drop to 6V - Using an ammeter to measure the current through the load is above 930A

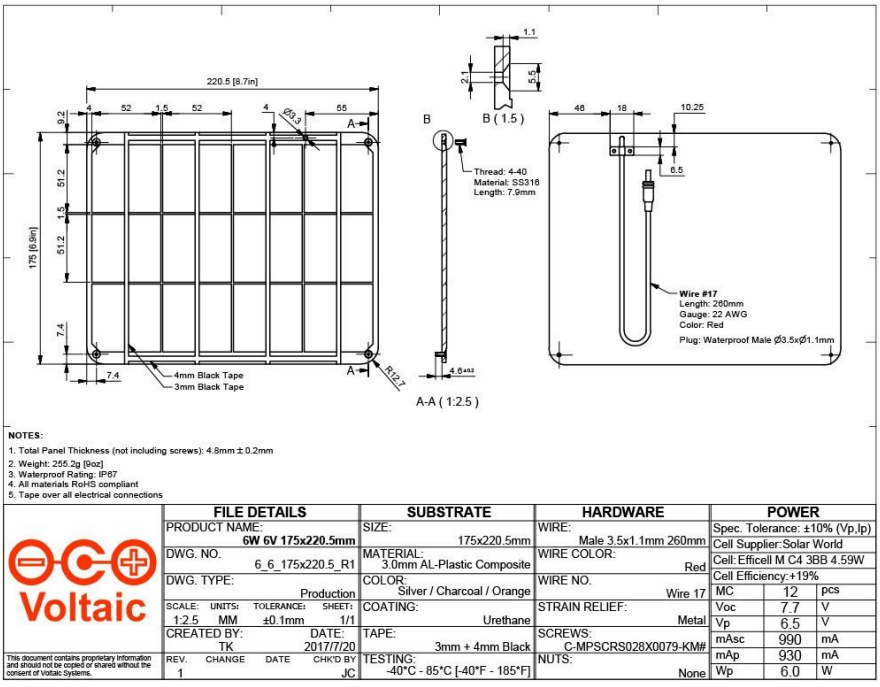

Fig. 4. Technical drawing of solar panel

2.1.2 Charging Module

The charging module will take the 5-10V input from the solar panel and steps the voltage down to charge up the battery pack. The current output from the solar panel is 930-990mA and the current rating for the charging module is chosen to be 1.5A max which makes sure that it will never go over the charging rate limit of the charging module. The 6600mAh battery pack will be fully charged in about 7 hours. The charging module is also designed to always draw the most amount of current from the solar panel in the light. Additional feature that is useful on this charging module is two LEDs. One indicating when there is power going through the charging module and the other one indicating when the battery is charging.

Requirement	Verification
Output 930-990mA between 3.7-4.4V when solar panel is exposed in the sun	- Expose the solar panel under the sun - Measure the open-circuit voltage with a voltmeter, ensuring that it is below 4.4V and above 3.7V - Measure the operating current with a multimeter, ensuring that it is between 930-990mA

2.1.3 Li-ion battery pack

The lithium ion battery pack used for this project is made of 3 balanced 4.2V 2200mAh cells for a total of 6600mA capacity. The cells are connected in parallel and spot-welded to a protection circuit that provides over-voltage, under-voltage and over-current protection to ensure the safety of this project. The maximum output current this battery pack can provide is 3.3A, 1.1A for each cell. The recommended constant current draw is under 1.3A. Since the servo that controls the opening and closing of the lid does have a maximum current draw of 2.6A, this battery is powerful enough for both the PCB board and the servo.

Fig.5 shows a rough power consumption diagram for the ATMEGA328P microcontroller chip that we will be using for this project. The last column on Fig. 5 shows that at 5V 16Mhz, the power consumption is about 80mW, which means it's drawing a 16mA current at 5V. Assuming idle, this battery pack will be able to power the board for 410 hours and when factoring in the instant power consumption from the motor when someone is using the dumpster, this battery capacity at 6600mAh is sufficient enough to provide at least 48 hours of battery life for the system without charging through the solar panel. This battery pack is also able to be fully charged by the solar panel for about 7 hours.

Requirements	Verification
Stores > 6600mAh of charge	- Using the already verified working solar panel and charging module, connect the battery pack to the charging module and expose the solar panel under the sun - Ensure the battery is getting charged through the solar panel by looking at the LED on the charging module - Expose the solar panel under the sun for about 7 hours, ensuring that the battery will get fully charged, can be verified by looking at the LED on the charging module - Connect the battery to a constant current test circuit and discharge the battery at 600mA for 11 hours - Use a voltmeter to ensure that the battery voltage remains above 3.7V

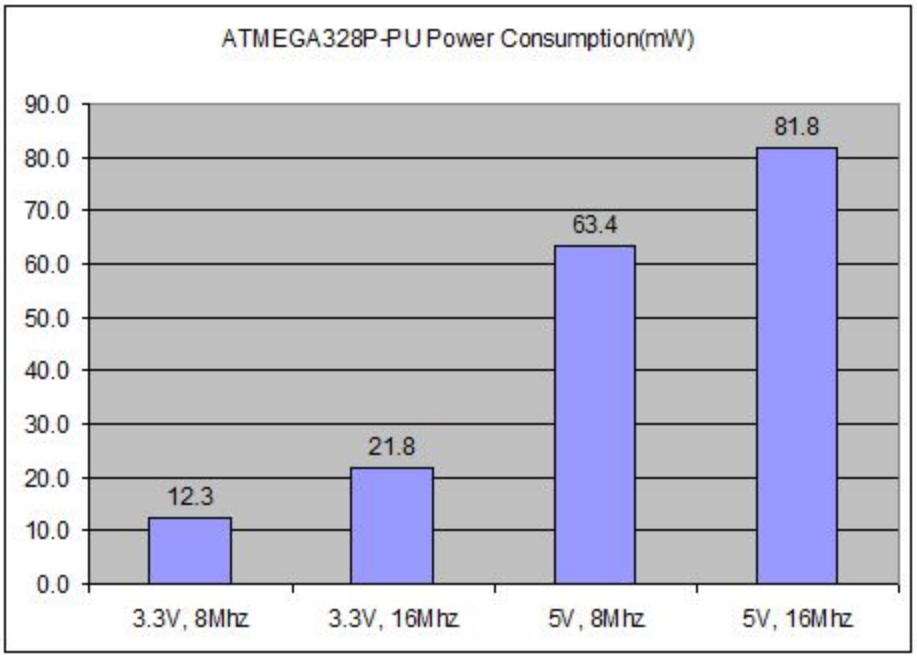

Fig. 5. ATMEGA328P Chip Power Consumption

2.1.4 Voltage Regulator

Two voltage regulators will be used for the system, one boost converter converting the 3.7-4.2 battery output to 5V to power up the PCB board and the other one which is designed on the PCB board converts 5V voltage to 3.3V. The 5V is used to supply power to the servos and sensors as well as powering up the microcontroller chip and the 3.3V is used for the RFID reader. The 5V boost converter will provide a 5V constant voltage output at 1A. The boost converter will take an input of 0.5-5.5V and has a current limit of 3.7V. At a 4V DC in, which is about the nominal voltage for a li-ion battery, the maximum current output is 1400mA, which should be enough for the system. Fig.6 shows the circuit schematic of the 5V to 3.3V voltage regulator that will be designed and used on the PCB board.

Requirements	Verification
- Provides 5V +/- 5% from a 3.7-4.2V source - Provides 3.3V from a 5V source	- Connect the input of the battery to the regulators - Measure the output voltage using a voltmeter or using an oscilloscope, ensuring that the output voltage stays within 5% of 5V - Provides a 5V to the PCB board - Measure the output voltage of the 3V3 regulator using a voltmeter or an oscilloscope, ensuring that the output voltage stays within 5% of 3.3V

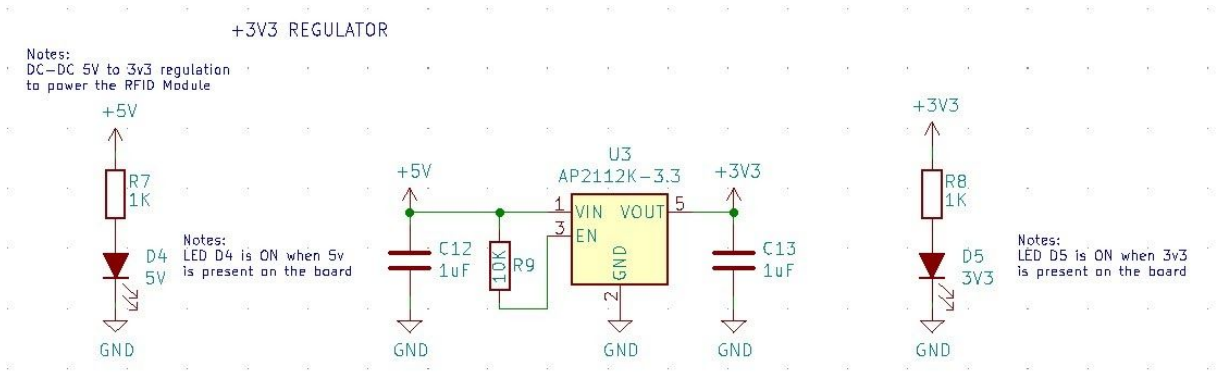

Fig. 6. 5V-3.3V voltage regulator for RFID reader

2.2 Unlock Group

The user of the dumpster will be able to simply scan their S50 card and be able to unlock the dumpster. This unlock group is the most essential part of the design, as the main difference between the current existing dumpster and Smart Dumpster is its security. Also, after unlocking the dumpster, the dumpster will automatically open, which prevents the hassle of the user having to open the heavy lid of the dumpster.

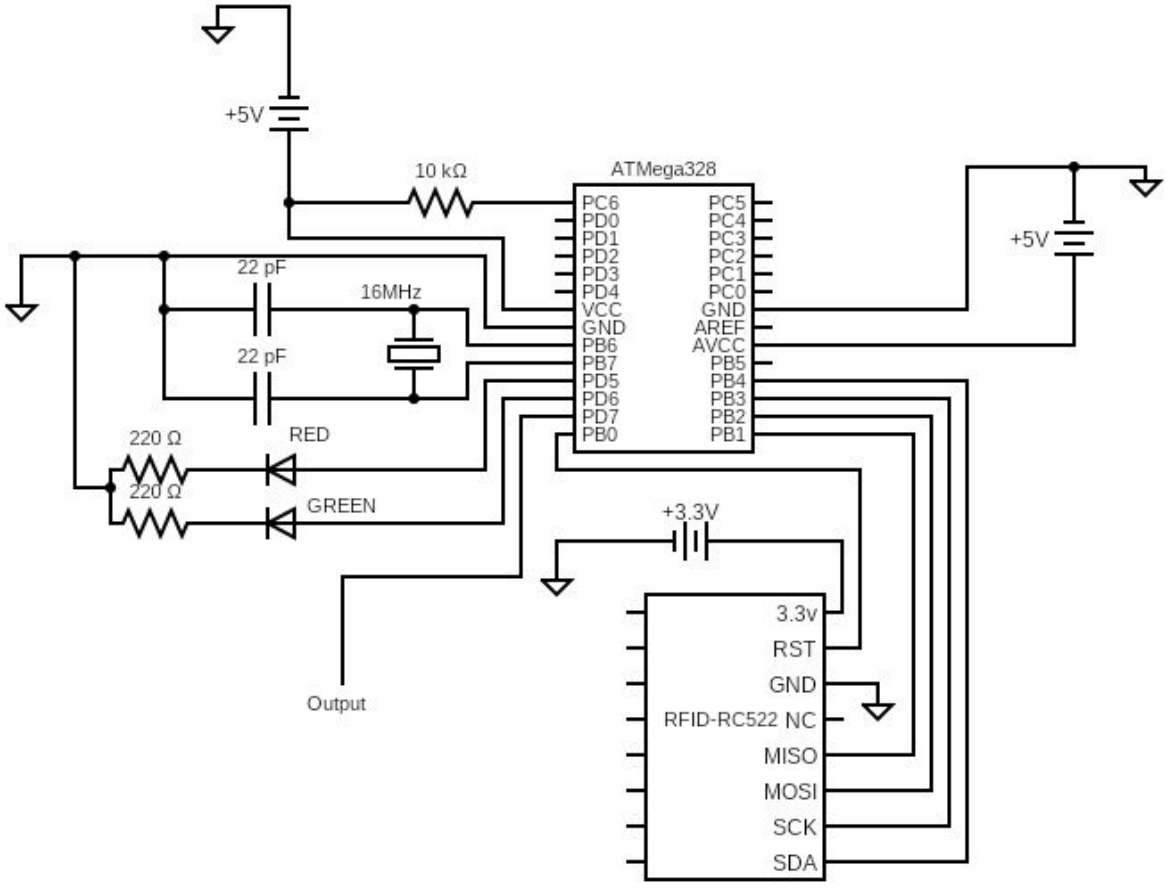

Fig. 7. RFID Reader Circuit Schematic

As the RFID-RC522, or RFID reader, reads the S50 cards, the reader will output the unique UID of the card to the ATMega328 chip. The microcontroller then will read whether the card is a valid card or not, and will output the necessary voltages to the correct pins. In pin PD5, it will output voltage HIGH when the card is not valid, thus flashing red LED. In pins PD6 and PD7, it will output voltage HIGH when the card is valid, thus making the green LED to flash and the output (PD7) to have a voltage. For both LEDs, the voltage will only be supplied for 5 seconds, to let the user know that the card it scanned is either wrong or right. The voltage for PD7 will be HIGH for 30 seconds, or until the lid comes back down.

2.2.1 RFID Card

This card will serve as the verification system for the users who have access to the dumpsters. Each RFID reader will have a unique tag, or transponder, that will allow the RFID reader to know whether the user has access to the dumpster or not.

The RFID reader will be a simple card with a tag, or transponder, in the middle of the card. This is a passive component, which consists of an antenna and an electronic microchip. When it gets near the electromagnetic field of the RFID reader, the induction will cause the voltage to be generated in its antenna coil. This will serve as power for the microchip in the card. From the power it receives, it will send the message back to the RFID reader, which will read the data in the transponder and decide whether the card is valid or not.

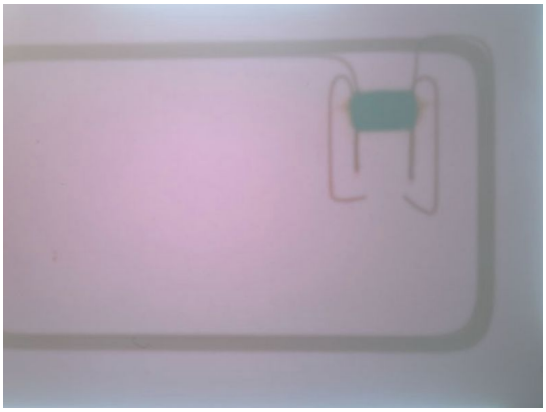

Fig. 8. RFID Tag

Requirements	Verification
- Provides the operating frequency of 13.56MHz - Has a unique UID number - Has an operating distance up to 10cm	- Check whether the RFID card had been registered to the RFID reader - Place the RFID card nearby the RFID reader - Check whether the RFID reader responds with an appropriate response (Red for invalid access and Green for valid access)

2.2.2 RFID Reader

The RFID reader's range is 33mm, and it will use the VCC of the module with 3.3V. The pins will be connected with the microcontroller according to the schematic. The RFID reader will read the

unique UID number when the card comes to the operating range, and can output the UID number to the microcontroller.

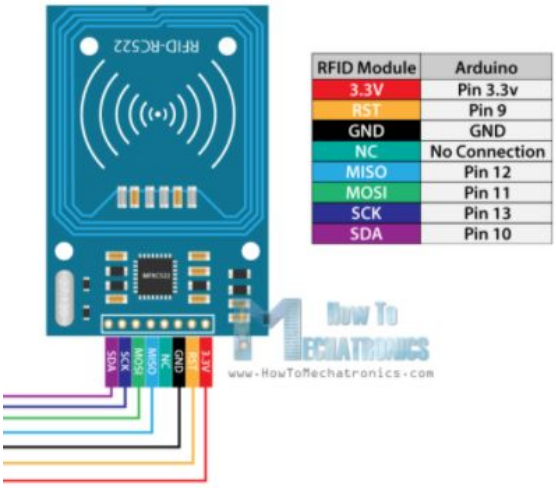

Fig. 9. RFID Reader

Requirements	Verification
- Provides the detection of 13.56MHz from the RFID card - Provides range up to 33mm - Able to output the unique UID number of RFID card it reads	1. Arduino Console Open - the MFRC522 library that outputs the detected UID can be seen 2. Arduino Console Not Open - Check whether the RFID card had been registered - Place the card on the RFID reader - Check whether the appropriate light flashes (Red for invalid and Green for valid)

2.2.3 Microcontroller

ATMega328 microcontroller will be used to store the verified RFID cards. These UIDs will be stored in the chip's memory. It will have 32Kb Flash Memory, 2Kb SRAM, and 16MHz clock (similar to that of an Arduino). When the correct RFID card is scanned, the chip will notify one of its pins, PD7, to trigger the unlocking of the lid. It will also command the red LED to flash when the RFID card is not valid (not stored in the memory) while the green LED will flash when the RFID card is valid.

We will be programming ATMega328 with arduino code. This will be written in simple C++ language. It will receive its input from the RFID reader, and to read the correct inputs or UID derived from the reader, the MFRC522 library will be used. This will allow the UID of the RFID card to be stored in an array format, and will trigger certain pins (PD5, PD6, PD7) when it receives the input to execute the lock and unlock.

Requirements	Verification
- Provides 32Kb Flash Memory - 2Kb SRAM - Pins that can serve as inputs and outputs - Compatible to coding in Arduino	- Place the registered RFID card on the RFID reader - Observe whether the LED light flashes green and triggers the unlocking

2.2.4 Lock and Unlock Mechanism

We will be using solenoid lock to secure the dumpster lid. It will have an input voltage of 12V, and when the voltage is inputted, the bar will go in (making the dumpster to unlock), and the lid will automatically open up. The bar will go out (making the dumpster to lock) when the lid comes down (after 30 seconds) when the voltage is no longer supplied. This will be controlled by the microcontroller in pin PD7 (output).

Requirements	Verification
- Provides input voltage of 12V - Built with iron material that is strong enough to not break with human power - Matches the timing of the lock and unlock with the lid (30 secs) - Bar in the solenoid lock goes in when the voltage is supplied - Bar in the solenoid lock goes out when the voltage is not supplied	- Simply check whether the solenoid lock works by triggering the voltage on its input ● The bar goes in when the voltage is supplied ● The bar goes out when the voltage is not supplied

2.2.4 Automatic Lid Opener

After the dumpster is unlocked, the servo will automatically be activated to open the lid via the microcontroller chip and the lid will be closed after 30 seconds. The servo chosen for this project will be a TowerPro MG996R servo that operates between 4.8V and 6.5V. It will offer torque between 9.4-11kg/cm and a speed of rotating 60 degrees in 0.17s. This is sufficient enough for lifting up the dumpster lid which will be made out of plastic.

Requirement	Verification
- Takes an input of 4.8-6.5V and offers a torque of 9.4-11kg/cm	- Supply a voltage of 4.8V to the input of the motor - Place a 9.4kg weight connected to one end of a 1cm stick with the other side connected to the motor, ensuring the motor can rotate with the weight attached - Supply a voltage of 6.0V to the input of the motor - Place a 11kg weight connected to one end of a 1cm stick with the other side connected to the motor, ensuring the motor can rotate with the weight attached

2.3 Message Group

The message group, ultrasonic distance measuring unit, is installed on the inside of the top cover of the dumpster and consists of two parts: ultrasonic sensor and signal transmitting unit.

2.3.1 Ultrasonic Sensor

It is used to determine whether the garbage can is full or not through the principle of acoustic reflection, and sends a signal to the reminding device when the dumpster is full. Every time the top cover is closed, the dumpster uses the ultrasonic distance measuring unit, HC-SR04, on the inside of the top cover to detect whether the dumpster is full or not. If it is full, it sends a signal to the app on the phone through the wireless transmitter. We will design our own PCB schematic with the Arduino chip to implement this functionality, which is different from the Arduino board.

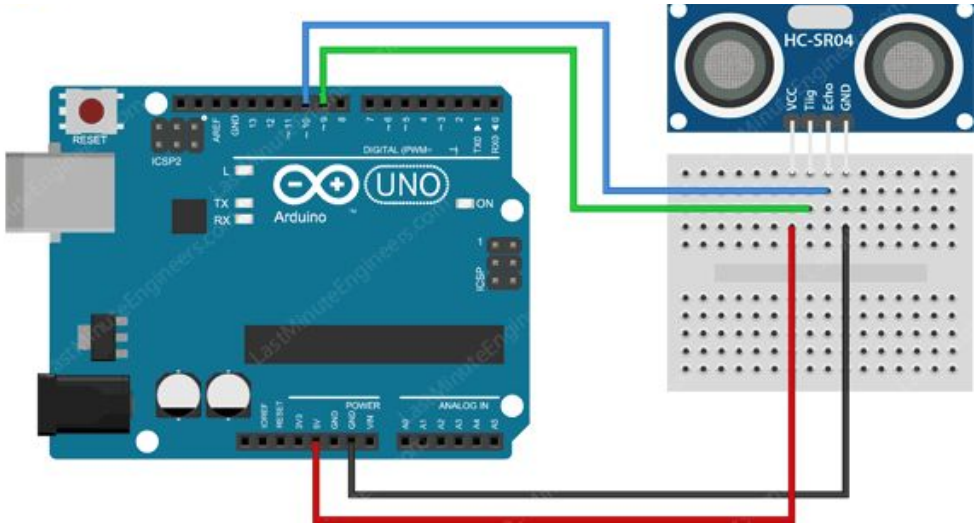

Fig. 10. Verification of HC-SR04

Requirement	Verification
- Measure Angle: 15°. - Ranging Distance: 2cm - 4m. - Accuracy can be up to 3mm.	- Connect the VCC pin to the 5V pin on the Arduino and connect the GND pin to the Ground pin on the Arduino. - In response, the sensor emits an eight-pulse sonic burst at 40 kHz, each pulse lasting at least 10 seconds. - To begin forming the echo-back signal, the Echo pin is set to HIGH. - If those pulses are not reflected back, the Echo signal will timeout and return low after 38 mS (38 milliseconds). - As a result, a 38 mS pulse means that there is no obstruction within the sensor's range. - Otherwise, It will produce a pulse with a width varying from 150 seconds to 25 milliseconds.

2.3.2 Wireless Signal Transmitter

This information, ESP8266 WiFi Module, will be connected along with the wireless signal transmitter to notify the app when the dumpster is full or not. Along with the ultrasonic sensor, this will send information whenever the top cover is closed after the ultrasonic sensor outputs the

information, which it will send the output to the wireless signal receiver (phone app). We will design our own PCB schematic with the Arduino chip to implement this functionality, which is different from the Arduino Due board.

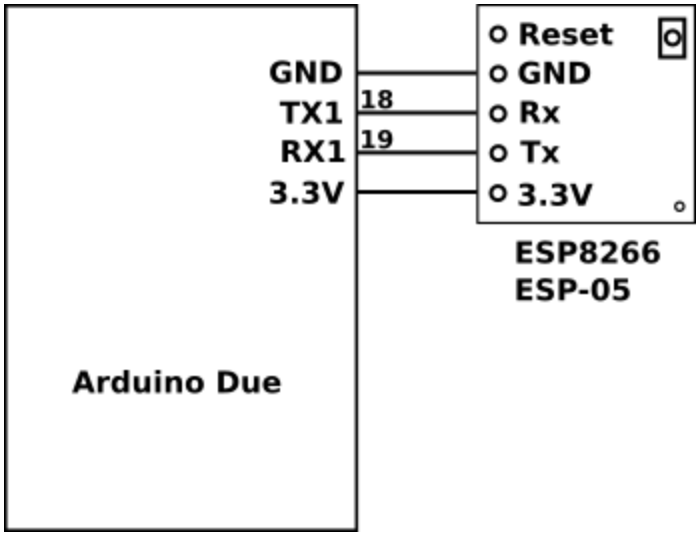

Fig. 11. Verification of ESP8266

Requirement	Verification
- The wifi frequency range is 2.4G~2.5G(2400M~2483.5M). - The operating voltage is 2.5V~3.6V. - Average current value is 80mA. - The operating temperature range is -40℃~125℃.	- In this test, an Arduino Due is used because its 3.3V pin can provide enough current to power the ESP8266 board. - The Due also has 3.3V I/O pins, making it compliant with the ESP8266 pins' logic levels.

2.4 Mobile Terminal Group

Each dumpster has its own number and signal transmitter, and the software on the phone will use a still map picture to mark the location of each dumpster and the degree of fullness, which informs the users of the availability of dumpsters. The verification is kind of simple that we just need to make sure that the app on the phone can successfully update the status of the dumpster regarding the actual fullness of it.

Requirement	Verification

- It can receive the signal from each wifi module on each dumpster.	- When it successfully receives the signal of the wifi module from the farthest apartment room away from the dumpster.

2.5 Tolerance Analysis

The majority of this project is pretty straightforward with tolerance limits of individual components not being a problem. However, an ultrasonic sensor is used for detecting the level of fullness for the dumpster which is a critical component where the accuracy of the measurements taken and the placement of the ultrasonics sensor within the dumpster can become an issue.

As mentioned before above, the ultrasonic sensor has two parts, signal transmitter and signal receiver. Each time when the lid of the dumpster closes, the ultrasonic sensor will send a pulse to the bottom of the dumpster, or when there is trash in the dumpster, to the top level of the trash contained in the dumpster. Once this pulse is bounced back, the algorithm of the sensor will calculate the distance between the lid and the current bottom of the dumpster by using the width of the received pulse. The distance between two objects by using the formula

Distance = Speed * Time

Suppose there is an object in front of the sensor at an unknown distance. The sensor received the bounced back wave with a wavelength of 1000 μS. The next step is to know the speed of the pulse. Since the ultrasonic sensor emits ultrasonic sound waves, it is safe to assume that the speed of the pulse is the speed of sound, which is 340m/s. Next by performing some unit conversion, the ultrasonic sound wave speed is 0.034 cm/μs. Then, the distance between the ultrasonic sensor and the unknown distance object can be calculated.

Distance = 0.034 cm/μs * 1000 μS / 2 = 17 cm

The division by 2 is necessary here because the time is for the ultrasonic wave to travel to the object and back. Thus, the distance between the ultrasonic sensor and the object is 17 cm.

This will lead to the accuracy and placement problem mentioned above. The HC-SR04 ultrasonic sensor has a resolution of 0.3cm, a measuring angle of 15 degree, and a detection range of 2-450cm. The most obvious problem that can cause inaccuracy here is the short detection range and the small measuring angle. The 15 degree measuring angle would suggest that there will be a significant blind spot close to the ultrasonic sensor. In fact, fig.12 which is included in the documentations for the HC-SR04 ultrasonic sensor shows the performance is the best in 30 degree angle. Since the ultrasonic sensor will be placed on the inside of the dumpster, this makes the placement of it extremely important. Placing the ultrasonic sensor directly in the center of the lid at a surface that is parallel to the ground will be the optimal solution since the higher region where the trash would

pile up would be most likely to be in the middle of the dumpster. This decision will give the data collected from the ultrasonic sensor a more accurate result.

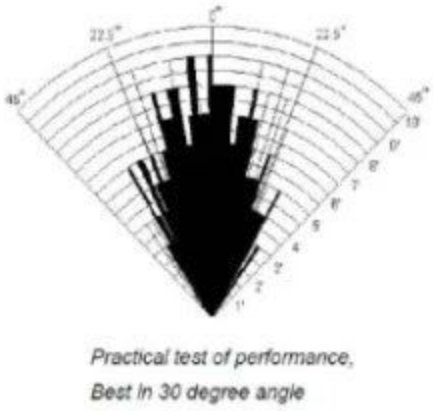

Fig. 12. Illustration of HC-SR04 ultrasonic sensor detection angles

The second consideration about this ultrasonic sensor is the type of object for the sensor to detect. The HC-SR04 ultrasonic sensor shows quality accuracy for detecting a hard surface like the distance to a concrete wall, but it falls short on detecting soft objects like cloth for example. Fig.13 shows the distribution time and length collected for measuring distance for a cloth placed at 67cm from the ultrasonic sensor. As shown in the diagram, comparing to the normal accuracy of ultrasonic sensor, the accuracy when measuring a soft object such as the cloth in the case is significantly lower due to the nature of soft object generally will have a more irregular surface and can absorb part of the ultrasonic sound wave rather than reflect it. These natures make soft objects difficult for the HC-SR04 sensor to detect. This can cause real issues for our project since trash bags are normally rather soft objects with irregular shapes. Without spending more money to purchase a stronger and more precise ultrasonic sensor like the JSN-SR04T, which comes in almost 10 times the price of the HC-SR04, the only other option is to have a larger tolerance for the accuracy of the fullness measurement. This approach can be utilized for this project due to the nature of the project and does not require extremely high accurate data for how full the dumpster is. The goal of this device is only to give a rough estimate of how full the dumpster is when it's not completely full so people can still come and use the dumpster and when it's completely full (trash is almost 2cm from the ultrasonic sensor) disable the unlocking mechanism so people cannot overfill the dumpster.

The final factor that may cause inaccurate measurements would be the effect of temperature. Since the dumpster is located outside, temperature can change dramatically between summer and winter in Illinois. Therefore, temperature should be taken into consideration when calculating for the speed of sound.

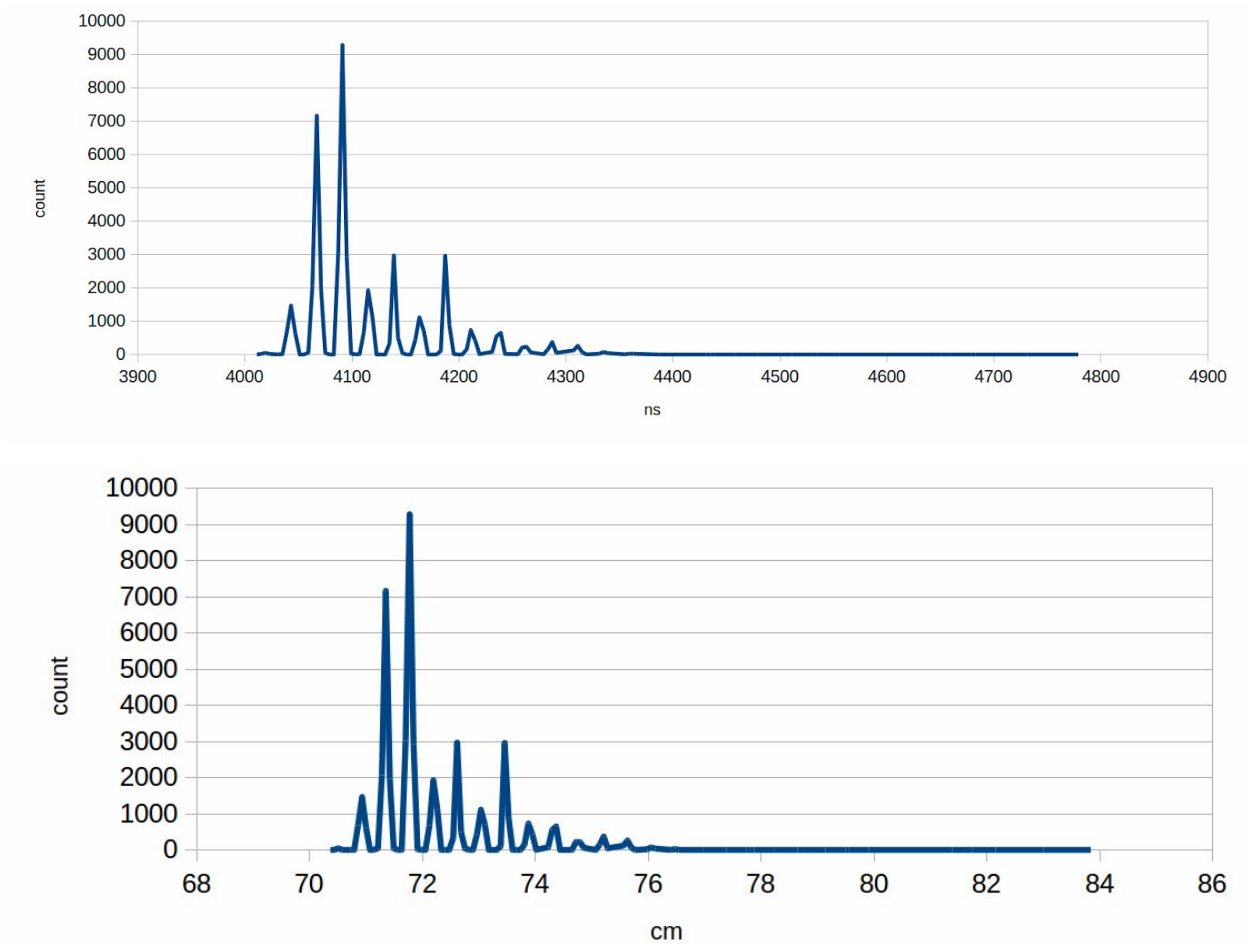

Fig. 13. Distribution time/length for cloth 67cm

The following formula can be used when calculating the speed of sound under the effect of temperature:

Speed of sound (m/s) = 331.4 + (0.606*Temperature(℃))

The level of fullness can be calculated using the height of the dumpster and the current height of the garbage. Since the height of the dumpster is unchanged, we can get the percentage of the height of the garbage and the height of the dumpster using the following equation:

$$\textbf{Fullness(\%)} = \frac{heigh\ of\ the\ dumpster - distance\ to\ garbage}{height\ of\ the\ dumpster}$$

Since the accuracy can be changed by all the different factors listed above, the level where the dumpster will be locked and not allowing anymore use can be changed based on the degree of accuracy.

3 Cost and Schedule

3.1 Cost Analysis

The cost of this project will be divided up into two parts: the labor cost and the parts cost. The labor cost is calculated through looking up the average salary for Engineering graduates from Illinois which is $78,714 for electrical engineers and $96,996 for computer engineers for the year 2018-2019. Therefore, the average salary for a ECE graduate would be:

$$ECE\ Graduate\ Average\ Salary\ = \frac{\$78{,}714 + \$96{,}996}{2} = \$87,855/year$$

On average, a full-time employee works about 1,801 hours per year, thus

$$ECE\ Graduate\ Average\ Salary = \frac{\$87{,}855}{1{,}801 hours} \approx \$48.8/hour$$

Finally, the labor cost for this entire project is calculated using this average salary per hour with an estimate of 3 people working 10 hours/week with a total of 16 weeks for the whole semester:

$$Labor\ Cost = \$48.8/hour \times 10\ hours/week \times 16\ weeks = \$7808$$

Parts that are used for this project and their costs are listed in the table below:

Part	**Price**
6V 6W Solar Panel (adafruit)	$13.98
3.7/4.2V 6600mAh Li-ion Battery (adafruit)	$12.25
RFID Reader (SunFounder RC522) + RFID Card	$6.99
Ultrasonic Distance Sensor (HC-SR04)	$2.00
Lock/Unlock Micro Servo (SG90)	$2.25
Lid Open/Close Servo (Tower Pro MG996R)	$17.95
Microcontroller (Digikey, ATmega328P-AU)	$2.32
Charging Module (adafruit, bq24074)	$9.95
Assorted resistors, capacitors, ICs, crystals, sockets (Digikey; est.)	$10.00

Arduino Wifi Module (EspressIF; ESP8266)	$1.75
Solenoid Lock (Pomyaip2ucv8h14)	$6.79
Total	**$86.23**

3.2 Schedule

Week	Yisi	JooYong	Qihang
3/8/21	Lock/unlock mechanism, connect and test RFID, lock/unlock servo, and Arduino		Begin programming lock/unlock using RFID reader and Arduino
3/15/21	Complete lock/unlock mechanism using RFID card, start lid open/close mechanism, connecting the open/close servo onto the Arduino		Modify existed codes to add open/close function after unlock
3/22/21	Testing the delay between unlock and open, make sure everything works from unlock the door to open the lid then to the lid closing		Bugfix the existing codes, begin constructing the mobile application
3/29/21	Test and connect the ultrasonic distance sensor and Arduino and work on the communication between the Arduino to mobile app through Wifi		Continue to work on communication between app and Arduino
4/5/21	Finish up with the ultrasonic distance sensor and the mobile application communication		Finish up the mobile application
4/12/21	Conduct environmental testing without the solar panel power supply		Continue debug the mobile application
4/19/21	Construct power supply using solar panel and power pack, test the charging rate and power output rate		Prepare for final presentation begin and final report
4/26/21	Conduct testing using the solar power supply		
5/3/21	Prepare for final presentation, final report		

4. Ethics and Safety

We have several concerns with our project. Due to using the lithium-ion battery, wires, electronic parts, and harsh outside conditions in which our dumpster will be at, the machine faces many risks and vulnerabilities that must be addressed.

First, there will be circuits and wires throughout the dumpster that connect the solar panel to the RFID reader and the ultrasonic sensor. We have to make sure that no matter the content of the garbage that will be inside, whether that would be liquid or solid, it will be able to work functionally. Due to the nature of these dumpsters exposed to a harsh environment, we have to make sure that it can withstand the extreme temperatures and the potential damages that it might face. Otherwise, the wires might be exposed and electrocute the user.

In order to solve this issue, we will cover the wires that connect with the solar panel to be covered with thick rubber that will be extremely difficult for these wires to be destroyed. Also, the solar panels and the RFID reader will be covered with thick, transparent plastic that will receive sunlight and enable the users to know where to scan the keycard to open the dumpsters.

A second concern is when the lid opens up the dumpster, the speed of the opening might catch some people off guard and injure other people. We have to make sure that the lid opens at an appropriate speed where people can notice the opening of the lid but not too slow to delay the users. Also, putting heavy objects on top of the lid can lead to mechanical failure that will break the motor and swing the lid in an unpredictable way. In order to prevent this, we will calculate the torque necessary to open the lid and not damage the users.

Third concern is the vulnerability of users being able to break open the lid and break the whole system, thus causing sensors to damage and electronic failures that might cause unforeseen shock and accidents. In order to prevent this, other than the RFID reader and the solar panels, we have tried our best to put the parts inside the dumpster. This will help us prevent any damages that might potentially damage the parts. Also, the RFID reader and the solar panels, like mentioned before, will be covered with transparent, protective shields that will be difficult to break.

We will vigorously test our designs so that the end product of our dumpster will be very safe. This will enable us to prevent any potential safety hazards and unforeseen design flaws. We will comply with IEEE code to seek and accept any criticisms and error that comes with the invention. Like mentioned before, we will make sure that our design will be safe, and have its safety to be the top priority in everything we do.

5. Citations

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