Executive Summary

The Reminder Roll was designed in an attempt to solve the widespread problem of using the restroom and realizing afterwards that the toilet paper is out. The solution, *The Reminder Roll,* automatically senses when the toilet paper within a stall is running low and sends a bluetooth signal to a device or customer service desk. The prototype developed in Project 2, does not use a bluetooth signal due to lack of materials and funds. It uses a light to remind users that the toilet paper is empty in an obvious way. In addition to changes in the "alert" system, *The Reminder Roll* prototype features an automatic dispensing system for toilet paper. This drastically increases the sanitation on *The Reminder Roll*. In conclusion, *The Reminder Roll* prototype built for Project 2 does solve the problem it set out to, just in a different way than originally planned.

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1 Introduction

Guy Fieri was walking through his local Walmart on the hunt for some smokey cayenne for his famous barbecue rib roast. Feeling the previous evening's fiery habanero bean burritos resurfacing, Guy rushed to the bathroom and sat down to answer the call of nature. Unbeknownst to him, to his immediate left, lay a problem that will haunt his most vile night terrors. He reached under the unsanitary, graffitied toilet paper holder and felt nothing but the sudden realization of horror, that he had no tissue to tidy his tushy.

Guy's story is one that every human being is bound to face at some point as active bathroom users. Maintenance workers and everyday restroom users need to be notified when toilet paper is out, because they want to avoid using the restroom and having no toilet paper to clean up. The mission of *The Reminder Roll* is to eliminate this scenario, by alerting the maintenance staff before and when the toilet paper dispenser is empty.

The Reminder Roll must include the following design requirements:

- Alert staff when toilet paper is almost out
- Ergonomic / easy to use and install
- Easily cleaned and kept sanitary
- Hold a maximum amount of toilet paper without exceeding the dimensions 18 X 18 X 6
- Unobtrusive and customizable aesthetic
- Affordable (~ $60)

This document will explore the design process and final prototype of *The Reminder Roll* in the following order:

- Background
    - Current Solutions
    - Customer Demographic

- Design and Implementation
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    - Code used in design

2 Background

2.1 Current Solutions

There is no market competition for a toilet paper holder that senses the amount of toilet paper available. Technology has been introduced to sense the amount of toilet paper, yet a product has never been introduced. Components of *The Reminder Roll* are available on the market, such as several designs utilizing the automatic dispenser technology to increase sanitation. That being said, none of these designs are marketed towards companies or department stores as *The Reminder Roll* is. *The Reminder Roll* is in a unique position where its only competitors are the regular toilet paper holders which create the problem *The Reminder Roll* is designed to fix.

2.2 Customer Demographic

As stated previously, *The Reminder Roll* is marketed towards department stores, malls, airports, etc. It is designed specifically to function in high traffic bathrooms in which toilet paper is used quickly, and a maintenance team is required to manually change the paper during scheduled bathroom inspections. We expect that once *The Reminder Roll* hits markets and begins to gain buyers, the convenience and reliability of the design in comparison toilet paper holders will cause more and more businesses to refit their bathrooms with *The Reminder Roll*. As old designs of toilet paper holders break or are graffitied to the point of replacement, we expect the market for this product to grow. In addition, as *The Reminder Roll* grows in popularity, more businesses will want the new best thing in restroom technology. (Think Dyson hand dryers)

3 Design and Implication

3.1 Design Details

The design for *the Reminder Roll* was to create a better toilet paper dispenser system. The casing for the toilet paper dispenser is to be made out of a lighter and less jagged material than that of usual cases. The most important feature of the design is the LED-light atop the design that will alert users when no more toilet paper is available. A feature also added was the ability for the toilet paper to be automatically dispensed at the discretion of a motion sensor. No other company has made a system that "reminds" a toilet user that no paper is left in the case. Our design will end awkward visits to the bathrooms where a user may embarrass themselves by having to ask another in a different stall for paper or worse: make a traumatizing mess. Although automatic paper towel dispensers have been made, no system automatically dispenses toilet paper. This is because the paper used on the delicate parts of our body is more delicate itself and therefore is more difficult to automatically dispense.

The Reminder Roll must include the following design requirements: it must be ergonomic, easy to use and install, easily cleaned and kept sanitary, unobtrusive and include customizable casing,

affordable by being about $60, hold a maximum amount of toilet paper without exceeding the dimensions 18 x 18 x 6, and alert staff when toilet paper is almost out/empty.

The overall theme is improvement of design rather than necessarily re-inventing. Some trade-offs of adding two sensors was an increase in cost. The way the design of the prototype was able to overcome the increase in cost of all the circuitry was to have the material be less expensive.

Customer feedback was hesitant at first with the idea of bluetooth. The original design incorporated a bluetooth system to relay information to a janitor or maintenance worker who would then promptly refill the toilet paper in the stall. The problem created by only incorporating bluetooth would be that customers would not be aware that the stall lacked toilet paper in the event that the custodial worker had not yet refilled the dispenser with toilet paper. With bluetooth, the distance from the internal sensor to the roll would have to be shortened in order to account for the necessary travel time of an employee to reach the stall to change the roll. If the alert was sent when the roll was empty, then people may enter the stall in the time it takes the worker to reach the restroom

3.2 Prototype Impact

The design has both economic and quality of life improvements to the original toilet paper casing design. On the economic standpoint the design uses less material in the overall casing piece. The polypropylene material that was used in the design was hollow in the middle which allowed for a lighter more ergonomic design and cut costs of materials. Additionally, quality of life is improved because the light alerts users of a lack of toilet paper and the automatic dispense system makes the design more sanitary. Less people have to touch the casing in an unsanitary environment which as a result makes the system cleaner and improves the quality of life. The theme of the project was to “design an automated solution for any of the spaces such as home, campus building including dorm, office, retail, restaurant, hospital, library, and factory”;

therefore, *The Reminder Roll* relates perfectly as it could be used in a majority of the spaces listed and produces value in an environmental and societal sense.

3.3 Prototype Images

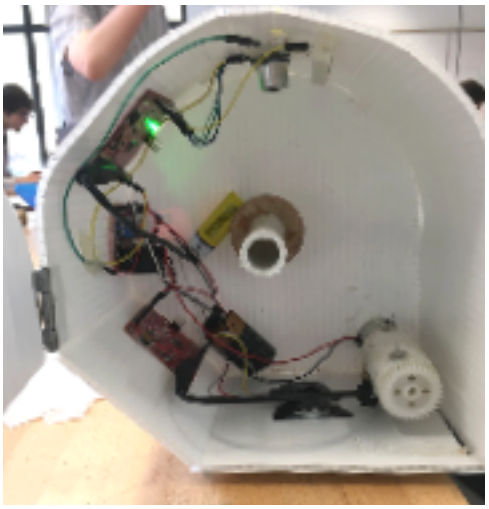

Figure 1: Front View of Design Without Toilet Paper

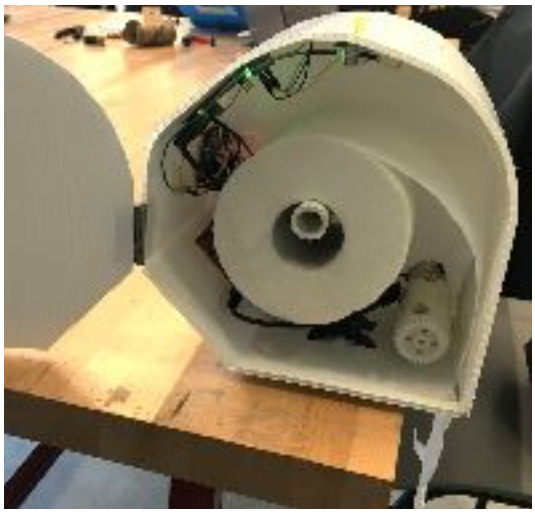

Figure 2: Front View of Design With Toilet Paper

Figure 3: Top View of Prototype

Figure 3: Closed Prototype

3.4 Materials and Cost

Table 1: Final Design Materials and Cost

Name of Component	Vendor	Unit Price	Quantity	Cost
Wires (20)	SparkyVille	0.10	20	2.00
12V DC Motor	SparkyVille	2.10	1	2.10
9V Battery	SparkyVille	2.40	3	7.20
Motion sensor	SparkyVille	7.55	2	15.10
Redboard	SparkyVille	19.95	1	19.95
Motor driver control	SparkyVille	4.00	1	4.00
resistor	SparkyVille	0.05	1	.05
LED light	SparkyVille	0.50	1	.50
Half breadboard (+/- only)	SparkyVille	0.76	1	.76
Polypropylene	Home Depot	8.00	1	8.00
Toilet paper roll	CVS	1.50	1	1.50
Total				61.16

Table 2: Prototyping and Testing Materials and Cost (Not Used in Final Design)

Name of Component	Vendor	Unit Price	Quantity	Cost
Stainless Steel Shim Shock	SparkyVille	3.60	1	3.60
Toilet paper rolls (extra)	CVS	1.50	2	3.00
Bluetooth Slave (refunded)	SparkyVille	7.39	1	3.18

Total	9.78

4 Results and Discussion

When testing the design, the prerequisites were that the toilet paper dispenser needed to hold the toilet paper, stay intact when the toilet paper is inserted, the wires would not unplug or lose connection, and the batteries would stay in place. The main goals of *The Reminder Roll* were that a light would turn on when the container was out of toilet paper and the motor would turn to automatically dispense toilet paper. To test if the system would hold toilet paper, an axle was made and placed in an appropriate spot to ensure the toilet paper roll would not touch the wires and other components of the Arduino. A difficulty with this test was that the axle was not secure enough to hold the roll, so it had to be anchored into the casing. Another difficulty was centering the axle around the correct point to ensure the paper would not run against the other components and get stuck. The test passed. Another test used was to ensure the light would turn on when the roll of toilet paper was nearly empty. The code was first written to turn the light on for a set distance. Then the distance from the ultrasonic sensor was measured to enter in the correct distance for the code. The light flickered at first since the sensor was measuring different distances due to its position. The ultrasonic sensor was then turned parallel to the toilet paper roll and the test passed. To test the code for the motor that was activated by the motion sensor, a hand was positioned within a certain distance. The ultrasonic sensor would not spin the axle of the motor at first until a piece of felt was removed as it was catching the motor.

The last test that was conducted was for the motor to automatically dispense the toilet paper. The beginning wheel placed on the toilet paper did not have enough friction to grasp the toilet paper. A longer axle was attached to the motor, but it also did not grasp the paper. Pins were added to the axle to pull the toilet paper down, but the toilet paper kept getting stuck on the spikes. Finally the motor was positioned enough of a distance from the wall to pull the paper without the toilet paper getting caught. The test for the toilet paper dispensing failed many times, before passing.

The design did not perform as expected for the final in-lab demonstration as the motor would not spin when the motion sensor was activated. This problem was resolved by the plastic being positioned to let the pins slide across to grab and release the toilet paper.
The design problem of people using the restroom and realizing afterwards that the toilet paper is out is solved as *The Reminder Roll* senses the amount of toilet paper left on the roll as well as alerts with a light when the roll is out.

5 Conclusions and Recommendations

Throughout the design process, the design changed a great deal, as there were problems constructing the prototype that were not accounted for in planning of the design. Initially, the motor was planned to be adjacent to the roll of toilet paper in order to make it unravel. However, as the toilet paper unravels, the radius of the roll would become smaller, resulting in the motor and the roll losing contact. Therefore, the design was altered to make the motor separate from the roll in order for the paper to unravel via the motor pulling on toilet paper. Initially, the casing was planned on being built out of sheet metal, but the material was very hard to work with, and a sufficient amount of material was not able to be acquired. As a solution, the casing was then made out of a cardboard-like plastic called polypropylene. Finally, the design originally would alert maintenance via bluetooth when the roll was low. However, after some logistical problems, the design was recoded to alert with a LED-light on the outside of the casing. Advances in coding ability were most definitely made through the process of trial and error as well as trying to understand how to link the bluetooth slave to Arduino.

Some takeaways from the project would be to plan for all aspects of the design before finalizing anything, such as the dimensions of the inside components as well as the width required when incorporating wires. Additionally, it is important to ensure all necessary components are available before beginning construction and to focus completely when given opportunities to work, which correlated to time management. For future projects, an individual should avoid

becoming too fixated on one design as it may change after prototyping and prepare to think critically.

To commercialize the design, it would be best to order products in bulk to lower the cost of materials as well as setup the the systems the same to avoid changing the code to fix new inputs. Perhaps plexiglass should be used as it is more durable, and the wires should be encased to avoid others tampering with the product. A bluetooth sensor could possibly be added to instantly alert maintenance, rather than employees checking the lights frequently. A larger, perhaps industrial roll could be used to delay replacement, therefore the dimensions of the casing would need to be adjusted.

References

No references were used, other than the example codes provided by Dr.
Chao Wang in Project 1 Lab: Construction and Testing under the link " additional tutorial with example code."

Appendix A: Detailed Engineering Drawing of Final Design

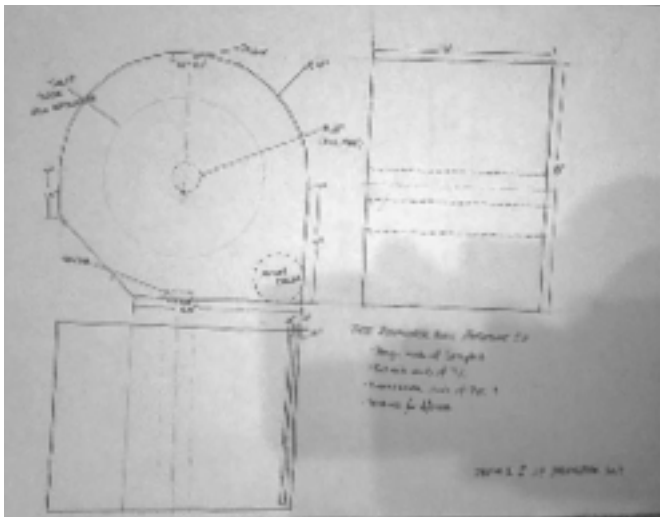

Figure 5: Engineering Drawing

Appendix B: Software Code

Code for motor activated by motion sensor (automatic dispenser system)

```
const int  IN1  =  4 ;  //set motor control pins
const int  IN2  =  5 ;
const int  speedPin = 3; //assign Enb to 3 on Arduino as the motor speed control, also used to enable motor
int trigPin = 9; // ultrasonic trigger on pin 9 output
const int echoPin = 10; // ultrasonic echo on pin 10 input

void  setup ()
{
 // set the pins as output from Arduino
 pinMode  ( IN1 ,  OUTPUT );     //assigned output of motor control board
 pinMode  ( IN2 ,  OUTPUT );
 pinMode  (speedPin ,  OUTPUT );
 Serial.begin (9600); // set up serial communication
 pinMode(trigPin, OUTPUT);
 pinMode(echoPin, INPUT);
}

void  loop ()
{
  // IN1 and IN2 work together to control the spin direction of the motor
  long duration;
  long distance; // define variables
  digitalWrite(IN1, LOW); //defined direction of spin
  digitalWrite(IN2, HIGH);  //" "
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(2);
  digitalWrite,(trigPin, LOW);

  // duration is the time in us from sending the signal to receiving the echo
  duration = pulseIn(echoPin, HIGH);
```

```
  // distance is the distance in cm from the object to the sensor
  // use the equation from the data sheet: distance(cm) = duration(us)/58
  distance = duration/58;
  Serial.println(distance);

    if (distance >= 2 && distance < 20) {

    //turn the motor on, when above distance is sensed
    analogWrite(speedPin, 100);
    Serial.println("dispensing");
    delay(2000);
    digitalWrite(speedPin,LOW);
    }
}
```

Code for LED activated by the Ultrasonic sensor:

```
const int trigPin = 8; // ultrasonic trigger on pin 8
const int echoPin = 7; // ultrasonic echo on pin 7
int LED = 13; //led pin

void setup() {
  Serial.begin (9600); // set up serial communication
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(LED, OUTPUT);    //defining LED pin
  digitalWrite(LED, LOW);  //once the program starts, it's going to turn off the led, as it can be
misleading
}

void loop() {
  long duration, distance; // define variables
  // generate the 10us pulse as the trigger signal according to the data sheet
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(2);
  digitalWrite(trigPin, LOW);
```

```
 // duration is the time in us from sending the signal to receiving the echo
 duration = pulseIn(echoPin, HIGH);

 // distance is the distance in cm from the object to the sensor
 // use the equation from the data sheet: distance(mm) = duration(us)/58
 distance = duration/58;
 Serial.println(distance);

  if (distance >= 0 && distance < 7.0) { // && represents AND
   digitalWrite(LED, LOW);
   Serial.println("light off");}
else if ((distance >= 7.0&& distance < 9.0)) { // && represents AND
   digitalWrite(LED, HIGH);
   Serial.println("light on");
}}
```