Accurate Consumption Utility Aid (A.C.U.A)

A Senior Design Report submitted to the
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of the University of Cincinnati

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Abstract

The senior citizen community is growing and the number of nurses is decreasing. Many senior citizens in nursing homes are dying because of malnutrition and dehydration; something as simple as making sure a person receives an adequate amount of fluid or certain diet is overlooked in an environment where this should be a concern. How can this problem be solved? What will make nurses' job easier so that they can make sure their elderly patients are consuming the correct amount of fluid and/or receiving the right amount of nutrition? In order to better fulfill this problem, creating a measuring device is sought. We researched sensors that measures weight, and the findings of many sensors were discovered; we tried to explore a load beam cell, but this was beyond our knowledge and would have taken too much time to discover the technical aspects of the part. Upon research, we discovered a sensor that seemed more ideal for our application, and that is the Flexiforce sensor. With this sensor, calibration is required and we took data points to make sure that the sensor's readings were linear so that we could obtain a formula to use in the code. There is a board, the Arduino Uno, that is a compatible with the sensor and it utilizes C/C++ base code which appeals to us because we have experience in this language. The next step was to figure out how do we use the sensor to measure accurately without much error and how do we plot the readings from the sensor into a spreadsheet. We came across a data acquisition tool, PLX, that is compatible with the Arduino program and can transfer data from the Arduino program to an excel spreadsheet. This was successful, but the major concern of this project is the accuracy and receiving a very low error rate.

Introduction

Problem

In today's society, the number of senior citizens is increasing, one reason being for the era of the baby boomers. A baby boomer is a person who was born during the demographic post-World War II baby boom between the years 1946 and 1964 and many of these individuals are going into nursing homes, retiring, or going into senior citizens homes; but there is very big issue surrounding nursing homes. There is becoming a shortage in nurses and this is very alarming because this means there will be a higher patient to nurse ratio. With this issue, nurses don't have time to dedicate their schedule to just one or maybe two particular patients. Nurses have very busy schedules in nursing homes, such as feeding the patients, changing their garments, bathing them, giving them their medication, and sometimes, even being a therapist for their patients because they are depressed. With all the work that needs to be done by a nurse, there is not enough time for them checking, watching what each of their patients consume and how much; and with this much room for error, many elderly patients in nursing homes die from dehydration and malnutrition because of the lack of watch and care that is dedicated to each patient. Something as simple as making sure a patient consumes enough fluid or gets the proper amount of nutrients is easily overlooked because of time. So what resourceful tool can solve this problem?

Solution

Liquid is said to be better consumed in the body than solids, and this fact can work for nursing home patients because most patients cannot consume solid foods, so they have to deal with liquid. Having a device that could deal with liquid and help keep track of the consumption of the patient's fluid intake would be something very resourceful for nurses. The Accurate Consumption Utility Aid (A.C.U.A) sole purpose is to deal with fluid. This design will help nurses to track the consumption of any fluid their patient drinks while not being too time consumed. A.C.U.A will simply have a measuring pad (that a designated bottle will sit on), the pad will take a measurement of the bottle (once the bottle is placed on the sensing pad), and the data will be tabulated in an excel spreadsheet with the measurement of the fluid in cups, milliliters, and fluid ounce with a time stamp. In this spreadsheet, the difference between the oldest and recent measurement is tabulated as well. This device will allow nurses to keep track of their patients intake of a specific liquid, or just simply water intake and allow them to tabulate the patients progress without them having to pick up a pen/pencil and paper to write down this information. With the information being on a computer, nurses can print out the results, save them to a flash drive, or even create their own graphs because the data is stored in excel.

Discussion

Project Concept

In order for the success of the device, finding the components to accomplish the goal is necessary. In order to get a reading from the bottle, some sort of sensor is needed. There are many types of pressure sensors that can be used and that takes measurements based off of the pressure applied to its sensing area and within the microcontroller this pressure can be converted to a number. A microcontroller is needed as well in order to read in the data the sensor is giving off and the microcontroller will have to be compatible with the pressure sensor in order for it to work together and finding a microcontroller that uses a language (such as C or Assembly) that can, within line(s) of code, transfer the data to excel is also needed.

Technical Approach

The Flexiforce Sensor is powered by the 5V terminal on the Arduino board and utilizes the A0 terminal on the board to read data from the sensor to the microcontroller. In the circuit, a 1MΩ resistor is used because it is approximately in the middle of the Flexiforce sensor's dynamic range.The circuit also utilizes a low pass filter to eliminate noise from the readings and a USB to serial connection is used to transfer data to the PC and into an excel spreadsheet. Below is an image that shows the connection of the sensor to the board.

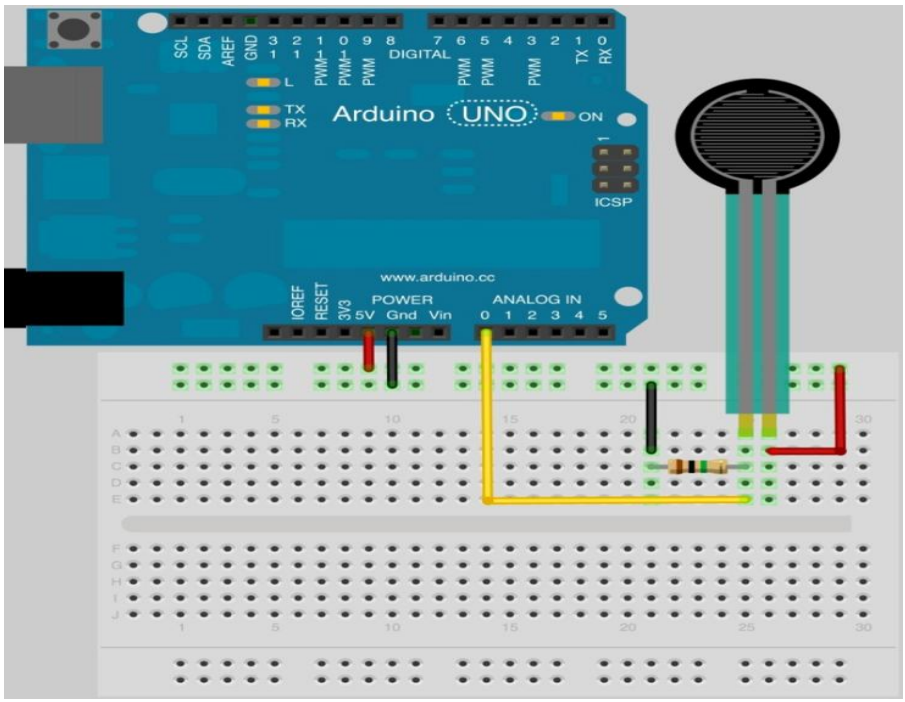

Figure 1: Arduino and Senor Connection

Hardware

Pressure Sensor

The sensor that is used in this project is a pressure sensor made from Teskan. The A401 force sensor is paper-thin at just 0.008” thickness. The sensing pad utilizes this sensor, which measures the force of the object in voltage and this is correlated to pounds. For this sensor, calibration is required for a more accurate reading. A formula is generated by plotting points of the amount of liquid in the bottle (mL) vs. the corresponding voltage; so the bottle was filled up with a certain amount of liquid (mL) and the corresponding voltage was recorded. This formula is used in the code to obtain more accurate results from the weight of the bottle. Before obtaining the formula, linearity is checked to make sure the formula is as accurate as possible. Below is Graph1, which show mL vs. Voltage.

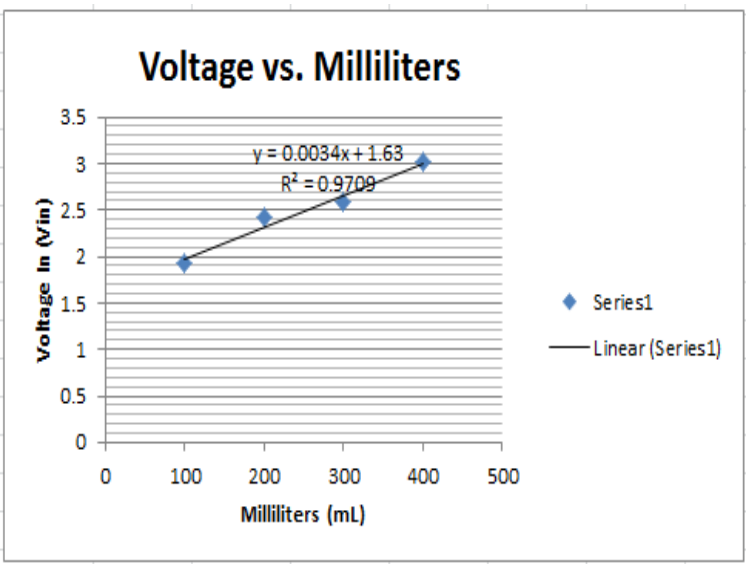

Figure 2: This graph shows the correlation between voltage and milliliters. And as can be seen in the graph, there is linearity between these two, and a formula is generated from this graph.

Arduino Board

The Arduino Uno is a microcontroller board based on the ATmega328. It contains everything needed to support the microcontroller and it can simply be connected to a computer with a USB cable or powered with a AC-to-DC adapter or battery. The microcontroller uses a language based on C/C++ language.

Software

Figure 3 shows a flow chart detailing how ACUA works. First, the bottle is picked up and then placed on the sensor where the voltage read in is converted to pounds, and pounds are converted to mL, fluid oz. and cups.

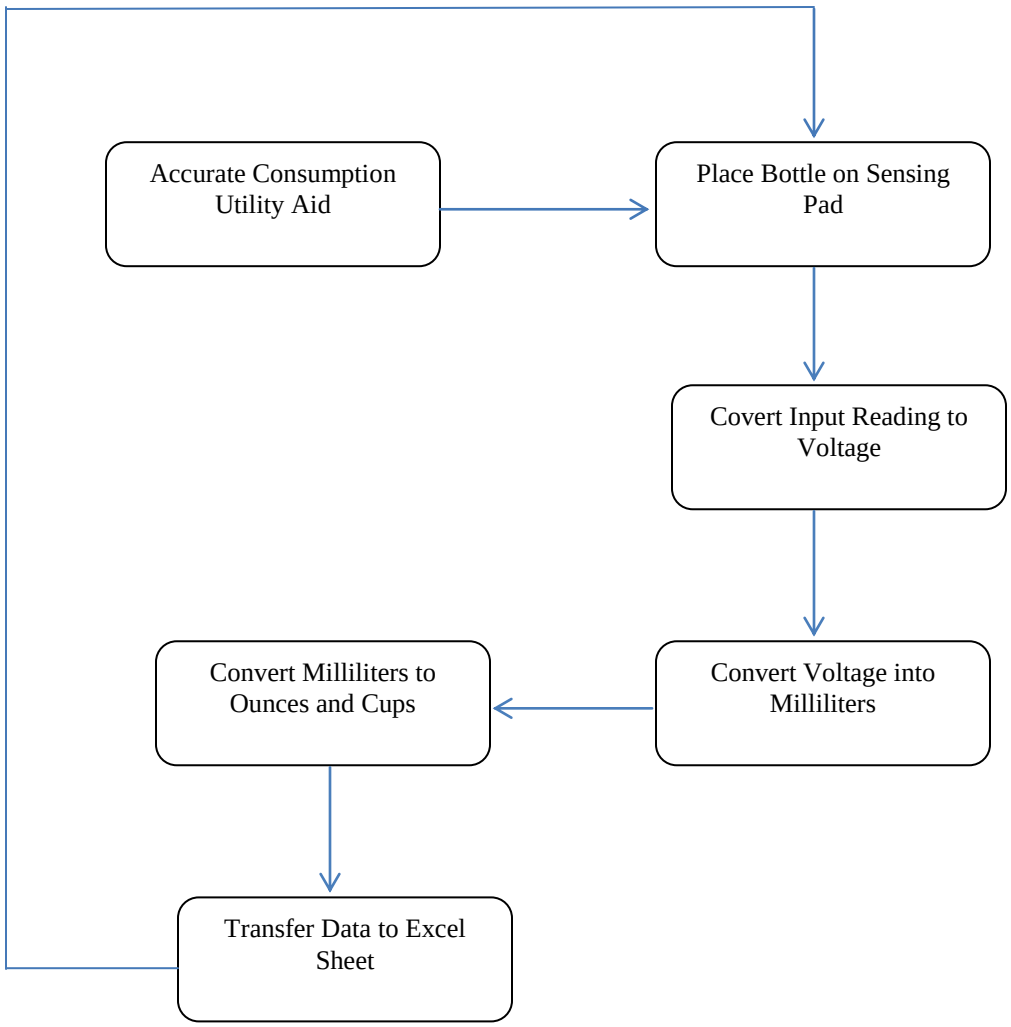

Figure 3: Flow Chart of how A.C.U.A works

Microsoft Excel

Excel is one of the more popular tools to use when it comes to creating tables, charts and plotting data so we thought of it to be essential to this project. While searching for a way to transmit data from the Arduino board to excel, we found PLX-DAQ. PLX-DAQ is a data acquisition tool made by Parallax that simply reads in data through a serial/USB connection and transmits that data into Excel. The tool and the Arduino board were compatible with one another and it made for easy transmitting of data. The next figure shows our custom Excel sheet and the PLX-DAQ tool receiving data from the Arduino.

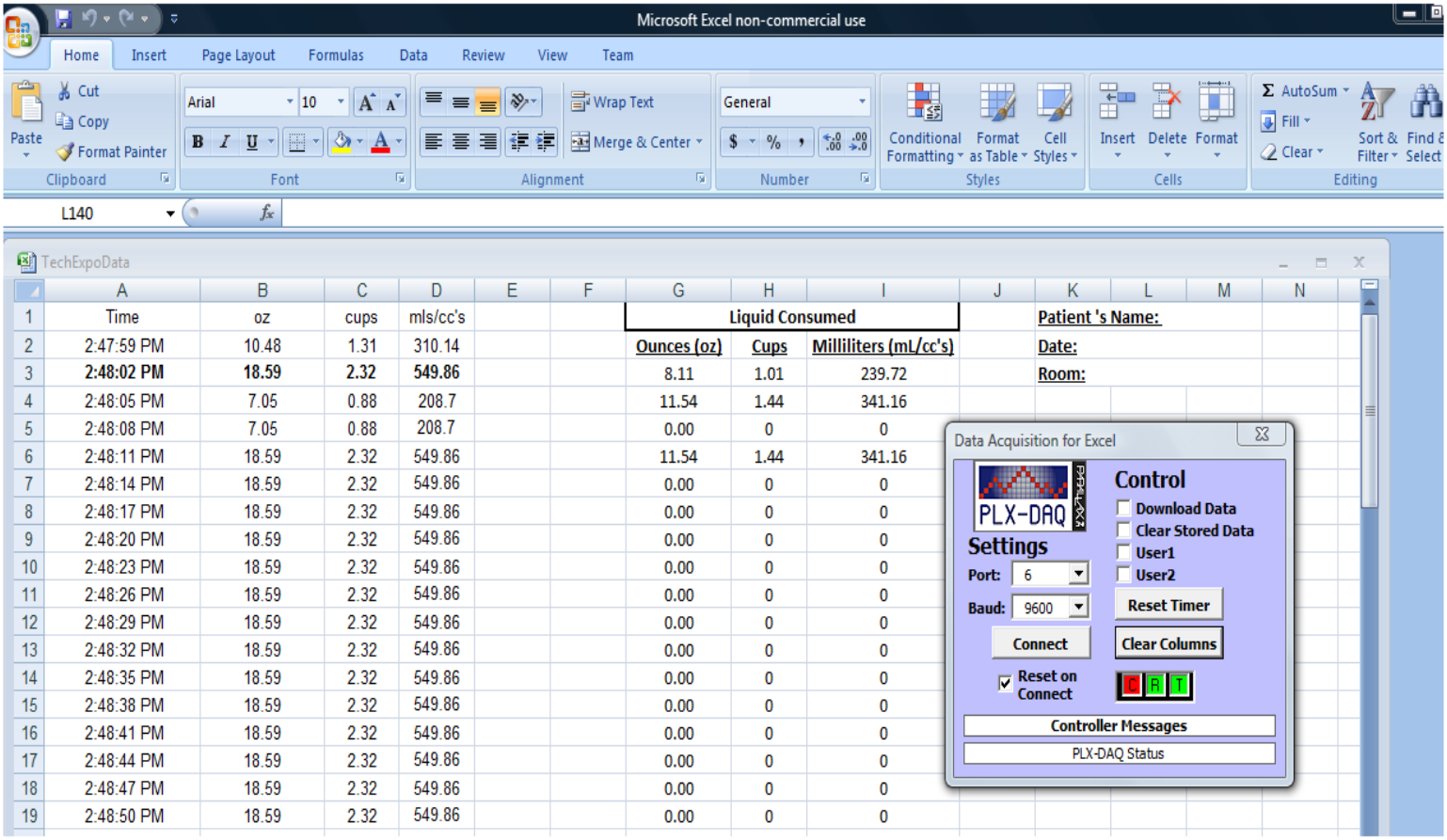

Figure 4: This figure shows the use of Excel and how the data outputted from the Arduino board is tabulated.

Budget

Table 1 outlines the cost of what it took to accomplish this project. The main items are listed with the price but the miscellaneous category is just parts or materials bought that were not needed or wasn't an electrical component; such as buying items for the enclosure.

Table 1: Budget Table

ITEM	PRICE
Arduino Board	$37
PRESSURE SENSOR	$100
WATER BOTTLE	$8
MISCELLANEOUS	$100
TOTAL	**$245**

Challenges Faced

The first challenge faced was finding a suitable microcontroller for the project. The first microcontroller that was utilized was a 771-JN5139 Jennic Wireless Microcontroller. The capabilities of this microcontroller included a wireless transmitter as well as analog to digital converter pins on the chip. We thought this would be a good microcontroller to use because it had all of these features, but after trying to use the microcontroller, we realize there would not be enough time to implement our project and moved on. Our next idea was to use Atmel 89C51RB2, the same microcontroller that was used in a previous course, embedded systems. We had already completed an analog to digital converter using this microprocessor so we figured this might be easier to implement, but because of the size of the board with the electrical components, we didn't use this and we wanted the project to be smaller; so we continued to research and came across the Arduino Uno board. The Arduino Uno came with everything necessary to power up the board, as well as its own compiler.

The next challenge was finding a pressure sensor. The first pressure sensor didn't seem to work the way we anticipated so it ultimately led to us trying a load beam cell. The issue with the load beam cell was that we didn't know if the signal coming off the data lines was an anolog or digital signal. With this issue, a search for another pressure sensor was sought and we discovered the Flexiforce Pressure sensor. Since this pressure sensor is compatible with the Arduino Uno board,

this is what we chose to move forward. Accuracy and precision of the flexiforce pressure sensor were the next issues to deal with.

In order to receive accurate results, the pressure sensor needed to be "conditioned" every time before use. The sensor was very sensitive when it came to placement of the bottle; so the output would change with the slightest movement. Depending on the placement of the bottle, there could be an accurate and then if placed again, there could be an inaccurate reading. This was somewhat fixed by placing a "puck" on the sensing area of the sensor. The puck is used so when force is applied, it is evenly distributed across the sensing area.

Precision was an issue because a small change in voltage could mean a significant change in milliliters. This was no longer an issue due to the code implemented on the software; but the other issue with precision was if the bottle sat on the sensor for a minute or so, the sensor would "drift". Drift is the change in sensor output when a constant force is applied over a period of time. If the sensor is kept under a constant load, the resistance of the sensor will continually decrease, and the output will gradually increase and this will produce inaccuracy. Unfortunately there was no way to avoid this issue as this is just part of the flexiforce sensor.

Future Improvements

We would like to find another pressure sensor, one that can be more accurate than the flexiforce sensor. We don't want a sensor that depends on placement as much as flexiforce does. As noted before, you could pick up the bottle, place it on the sensor and get inaccurate readings, then place it again and get an accurate reading. Also we want to go wireless because in a hospital environment, wireless will be beneficial for the simple fact that nurses would not have to worry about cables and wires.

Conclusion

Having this device will make the jobs of nurses simpler by giving them an alternate way of keeping track of fluids consumed by their patients. This device could and possibly will save patients' lives. How? Well, the nurses are so occupied with other patients they don't have time to monitor every patient and their health; and this device will make things much simpler by providing accurate results and the total amount of liquid consumption. By subtracting the previous reading from the current reading, the amount consumed can be obtained and used to create graphs and charts if necessary. A.C.U.A will also cut the time back for nurses because they don't have to manually measure liquid out, all the nurses have to do is place the device on the measuring pad and get an accurate reading. This device is effective, causing more accuracy in fluid in-take, and possibly saving lives.

Appendix A

```
void setup()    // Used in every Arduino program
{
  // Start serial at 9600 baud
  Serial.begin(9600);
  Serial.println("CLEARDATA");
  Serial.println("LABEL,Time,lbs,oz,cups,mls/cc's");  // Sets  column names for table in Excel

}

// Getting the Voltage
void loop()
{

  // Read the Input on analog pin 0
  int sensorvalue = analogRead(A0);

  // Convert analog reading to voltage
  float voltageone = sensorvalue * (5.0/1023.0) ;

/* The following code wasn't necessary but was put in place to make voltage readings more
precise so that conversions could be more precise */
if (voltageone >= 0.0 && voltageone <= 0.5)
  {
    voltageone = 0;
  }

  if (voltageone >= 0.5 && voltageone <=     0.51)
  {
    voltageone = 0.505;
  }
if        (voltageone >=          0.51     &&     voltageone <= 0.52     )
{
    voltageone = 0.515;
  }
if        (voltageone >=          0.52     &&     voltageone <= 0.53     )
{
    voltageone = 0.525;
  }
if        (voltageone >=          0.53     &&     voltageone <= 0.54     )
{
    voltageone = 0.535;
  }
if        (voltageone >=          0.54     &&     voltageone <= 0.55     )
```

```
{
   voltageone = 0.545;
  }
if       (voltageone >=       0.55    &&    voltageone <= 0.56    )
{
   voltageone = 0.555;
  }
if       (voltageone >=       0.56    &&    voltageone <= 0.57    )
{
   voltageone = 0.565;
  }
if       (voltageone >=       0.57    &&    voltageone <= 0.58    )
{
   voltageone = 0.575;
  }
if       (voltageone >=       0.58    &&    voltageone <= 0.59    )
{
   voltageone = 0.585;
  }
if       (voltageone >=       0.59    &&    voltageone <= 0.6     )
{
   voltageone = 0.595;
  }
if       (voltageone >=       0.6     &&    voltageone <= 0.61    )
{
   voltageone = 0.605;
  }
if       (voltageone >=       0.61    &&    voltageone <= 0.62    )
{
   voltageone = 0.615;
  }
if       (voltageone >=       0.62    &&    voltageone <= 0.63    )
{
   voltageone = 0.625;
  }
if       (voltageone >=       0.63    &&    voltageone <= 0.64    )
{
   voltageone = 0.635;
  }
if       (voltageone >=       0.64    &&    voltageone <= 0.65    )
{
   voltageone = 0.645;
  }
if       (voltageone >=       0.65    &&    voltageone <= 0.66    )
{
   voltageone = 0.655;
```

```
  }
if      (voltageone >=      0.66    &&    voltageone <= 0.67    )
{
   voltageone = 0.665;
  }
if      (voltageone >=      0.67    &&    voltageone <= 0.68    )
{
   voltageone = 0.675;
  }
if      (voltageone >=      0.68    &&    voltageone <= 0.69    )
{
   voltageone = 0.685;
  }
if      (voltageone >=      0.69    &&    voltageone <= 0.7     )
{
   voltageone = 0.695;
  }
if      (voltageone >=      0.7     &&    voltageone <= 0.71    )
{
   voltageone = 0.705;
  }
if      (voltageone >=      0.71    &&    voltageone <= 0.72    )
{
   voltageone = 0.715;
  }
if      (voltageone >=      0.72    &&    voltageone <= 0.73    )
{
   voltageone = 0.725;
  }
if      (voltageone >=      0.73    &&    voltageone <= 0.74    )
{
   voltageone = 0.735;
  }
if      (voltageone >=      0.74    &&    voltageone <= 0.75    )
{
   voltageone = 0.745;
  }
if      (voltageone >=      0.75    &&    voltageone <= 0.76    )
{
   voltageone = 0.755;
  }
if      (voltageone >=      0.76    &&    voltageone <= 0.77    )
{
   voltageone = 0.765;
  }
if      (voltageone >=      0.77    &&    voltageone <= 0.78    )
```

```
{
   voltageone = 0.775;
  }
if       (voltageone >=       0.78    &&    voltageone <= 0.79    )
{
   voltageone = 0.785;
  }
if       (voltageone >=       0.79    &&    voltageone <= 0.8     )
{
   voltageone = 0.795;
  }
if       (voltageone >=       0.8     &&    voltageone <= 0.81    )
{
   voltageone = 0.805;
  }
if       (voltageone >=       0.81    &&    voltageone <= 0.82    )
{
   voltageone = 0.815;
  }
if       (voltageone >=       0.82    &&    voltageone <= 0.83    )
{
   voltageone = 0.825;
  }
if       (voltageone >=       0.83    &&    voltageone <= 0.84    )
{
   voltageone = 0.835;
  }
if       (voltageone >=       0.84    &&    voltageone <= 0.85    )
{
   voltageone = 0.845;
  }
if       (voltageone >=       0.85    &&    voltageone <= 0.86    )
{
   voltageone = 0.855;
  }
if       (voltageone >=       0.86    &&    voltageone <= 0.87    )
{
   voltageone = 0.865;
  }
if       (voltageone >=       0.87    &&    voltageone <= 0.88    )
{
   voltageone = 0.875;
  }
if       (voltageone >=       0.88    &&    voltageone <= 0.89    )
{
   voltageone = 0.885;
```

```
  }
if      (voltageone >=      0.89    &&    voltageone <= 0.9     )
{
   voltageone = 0.895;
  }
if      (voltageone >=      0.9     &&    voltageone <= 0.91    )
{
   voltageone = 0.905;
  }
if      (voltageone >=      0.91    &&    voltageone <= 0.92    )
{
   voltageone = 0.915;
  }
if      (voltageone >=      0.92    &&    voltageone <= 0.93    )
{
   voltageone = 0.925;
  }
if      (voltageone >=      0.93    &&    voltageone <= 0.94    )
{
   voltageone = 0.935;
  }
if      (voltageone >=      0.94    &&    voltageone <= 0.95    )
{
   voltageone = 0.945;
  }
if      (voltageone >=      0.95    &&    voltageone <= 0.96    )
{
   voltageone = 0.955;
  }
if      (voltageone >=      0.96    &&    voltageone <= 0.97    )
{
   voltageone = 0.965;
  }
if      (voltageone >=      0.97    &&    voltageone <= 0.98    )
{
   voltageone = 0.975;
  }
if      (voltageone >=      0.98    &&    voltageone <= 0.99    )
{
   voltageone = 0.985;
  }
if      (voltageone >=      0.99    &&    voltageone <= 1       )
{
   voltageone = 0.995;
  }
if      (voltageone >=      1       &&    voltageone <= 1.01    )
```

```
{
   voltageone = 1.005;
  }
if       (voltageone >=       1.01    &&    voltageone <= 1.02    )
{
   voltageone = 1.015;
  }
if       (voltageone >=       1.02    &&    voltageone <= 1.03    )
{
   voltageone = 1.025;
  }
if       (voltageone >=       1.03    &&    voltageone <= 1.04    )
{
   voltageone = 1.035;
  }
if       (voltageone >=       1.04    &&    voltageone <= 1.05    )
{
   voltageone = 1.045;
  }
if       (voltageone >=       1.05    &&    voltageone <= 1.06    )
{
   voltageone = 1.055;
  }
if       (voltageone >=       1.06    &&    voltageone <= 1.07    )
{
   voltageone = 1.065;
  }
if       (voltageone >=       1.07    &&    voltageone <= 1.08    )
{
   voltageone = 1.075;
  }
if       (voltageone >=       1.08    &&    voltageone <= 1.09    )
{
   voltageone = 1.085;
  }
if       (voltageone >=       1.09    &&    voltageone <= 1.1     )
{
   voltageone = 1.095;
  }
if       (voltageone >=       1.1     &&    voltageone <= 1.11    )
{
   voltageone = 1.105;
  }
if       (voltageone >=       1.11    &&    voltageone <= 1.12    )
{
   voltageone = 1.115;
```

```
  }
if      (voltageone >=      1.12    &&    voltageone <= 1.13    )
{
   voltageone = 1.125;
  }
if      (voltageone >=      1.13    &&    voltageone <= 1.14    )
{
   voltageone = 1.135;
  }
if      (voltageone >=      1.14    &&    voltageone <= 1.15    )
{
   voltageone = 1.145;
  }
if      (voltageone >=      1.15    &&    voltageone <= 1.16    )
{
   voltageone = 1.155;
  }
if      (voltageone >=      1.16    &&    voltageone <= 1.17    )
{
   voltageone = 1.165;
  }
if      (voltageone >=      1.17    &&    voltageone <= 1.18    )
{
   voltageone = 1.175;
  }
if      (voltageone >=      1.18    &&    voltageone <= 1.19    )
{
   voltageone = 1.185;
  }
if      (voltageone >=      1.19    &&    voltageone <= 1.2     )
{
   voltageone = 1.195;
  }
if      (voltageone >=      1.2     &&    voltageone <= 1.21    )
{
   voltageone = 1.205;
  }
if      (voltageone >=      1.21    &&    voltageone <= 1.22    )
{
   voltageone = 1.215;
  }
if      (voltageone >=      1.22    &&    voltageone <= 1.23    )
{
   voltageone = 1.225;
  }
if      (voltageone >=      1.23    &&    voltageone <= 1.24    )
```

```
{
   voltageone = 1.235;
  }
if       (voltageone >=       1.24    &&    voltageone <= 1.25    )
{
   voltageone = 1.245;
  }
if       (voltageone >=       1.25    &&    voltageone <= 1.26    )
{
   voltageone = 1.255;
  }
if       (voltageone >=       1.26    &&    voltageone <= 1.27    )
{
   voltageone = 1.265;
  }
if       (voltageone >=       1.27    &&    voltageone <= 1.28    )
{
   voltageone = 1.275;
  }
if       (voltageone >=       1.28    &&    voltageone <= 1.29    )
{
   voltageone = 1.285;
  }
if       (voltageone >=       1.29    &&    voltageone <= 1.3     )
{
   voltageone = 1.295;
  }
if       (voltageone >=       1.3     &&    voltageone <= 1.31    )
{
   voltageone = 1.305;
  }
if       (voltageone >=       1.31    &&    voltageone <= 1.32    )
{
   voltageone = 1.315;
  }
if       (voltageone >=       1.32    &&    voltageone <= 1.33    )
{
   voltageone = 1.325;
  }
if       (voltageone >=       1.33    &&    voltageone <= 1.34    )
{
   voltageone = 1.335;
  }
if       (voltageone >=       1.34    &&    voltageone <= 1.35    )
{
   voltageone = 1.345;
```

```
  }
if      (voltageone >=      1.35    &&    voltageone <= 1.36    )
{
   voltageone = 1.355;
  }
if      (voltageone >=      1.36    &&    voltageone <= 1.37    )
{
   voltageone = 1.365;
  }
if      (voltageone >=      1.37    &&    voltageone <= 1.38    )
{
   voltageone = 1.375;
  }
if      (voltageone >=      1.38    &&    voltageone <= 1.39    )
{
   voltageone = 1.385;
  }
if      (voltageone >=      1.39    &&    voltageone <= 1.4     )
{
   voltageone = 1.395;
  }
if      (voltageone >=      1.4     &&    voltageone <= 1.41    )
{
   voltageone = 1.405;
  }
if      (voltageone >=      1.41    &&    voltageone <= 1.42    )
{
   voltageone = 1.415;
  }
if      (voltageone >=      1.42    &&    voltageone <= 1.43    )
{
   voltageone = 1.425;
  }
if      (voltageone >=      1.43    &&    voltageone <= 1.44    )
{
   voltageone = 1.435;
  }
if      (voltageone >=      1.44    &&    voltageone <= 1.45    )
{
   voltageone = 1.445;
  }
if      (voltageone >=      1.45    &&    voltageone <= 1.46    )
{
   voltageone = 1.455;
  }
if      (voltageone >=      1.46    &&    voltageone <= 1.47    )
```

```
{
   voltageone = 1.465;
  }
if       (voltageone >=       1.47    &&    voltageone <= 1.48    )
{
   voltageone = 1.475;
  }
if       (voltageone >=       1.48    &&    voltageone <= 1.49    )
{
   voltageone = 1.485;
  }
if       (voltageone >=       1.49    &&    voltageone <= 1.5     )
{
   voltageone = 1.495;
  }
if       (voltageone >=       1.5     &&    voltageone <= 1.51    )
{
   voltageone = 1.505;
  }
if       (voltageone >=       1.51    &&    voltageone <= 1.52    )
{
   voltageone = 1.515;
  }
if       (voltageone >=       1.52    &&    voltageone <= 1.53    )
{
   voltageone = 1.525;
  }
if       (voltageone >=       1.53    &&    voltageone <= 1.54    )
{
   voltageone = 1.535;
  }
if       (voltageone >=       1.54    &&    voltageone <= 1.55    )
{
   voltageone = 1.545;
  }
if       (voltageone >=       1.55    &&    voltageone <= 1.56    )
{
   voltageone = 1.555;
  }
if       (voltageone >=       1.56    &&    voltageone <= 1.57    )
{
   voltageone = 1.565;
  }
if       (voltageone >=       1.57    &&    voltageone <= 1.58    )
{
   voltageone = 1.575;
```

```
  }
if      (voltageone >=      1.58    &&    voltageone <= 1.59    )
{
   voltageone = 1.585;
  }
if      (voltageone >=      1.59    &&    voltageone <= 1.6     )
{
   voltageone = 1.595;
  }
if      (voltageone >=      1.6     &&    voltageone <= 1.61    )
{
   voltageone = 1.605;
  }
if      (voltageone >=      1.61    &&    voltageone <= 1.62    )
{
   voltageone = 1.615;
  }
if      (voltageone >=      1.62    &&    voltageone <= 1.63    )
{
   voltageone = 1.625;
  }
if      (voltageone >=      1.63    &&    voltageone <= 1.64    )
{
   voltageone = 1.635;
  }
if      (voltageone >=      1.64    &&    voltageone <= 1.65    )
{
   voltageone = 1.645;
  }
if      (voltageone >=      1.65    &&    voltageone <= 1.66    )
{
   voltageone = 1.655;
  }
if      (voltageone >=      1.66    &&    voltageone <= 1.67    )
{
   voltageone = 1.665;
  }
if      (voltageone >=      1.67    &&    voltageone <= 1.68    )
{
   voltageone = 1.675;
  }
if      (voltageone >=      1.68    &&    voltageone <= 1.69    )
{
   voltageone = 1.685;
  }
if      (voltageone >=      1.69    &&    voltageone <= 1.7     )
```

```
{
   voltageone = 1.695;
  }
if       (voltageone >=       1.7     &&     voltageone <= 1.71     )
{
   voltageone = 1.705;
  }
if       (voltageone >=       1.71    &&     voltageone <= 1.72     )
{
   voltageone = 1.715;
  }
if       (voltageone >=       1.72    &&     voltageone <= 1.73     )
{
   voltageone = 1.725;
  }
if       (voltageone >=       1.73    &&     voltageone <= 1.74     )
{
   voltageone = 1.735;
  }
if       (voltageone >=       1.74    &&     voltageone <= 1.75     )
{
   voltageone = 1.745;
  }
if       (voltageone >=       1.75    &&     voltageone <= 1.76     )
{
   voltageone = 1.755;
  }
if       (voltageone >=       1.76    &&     voltageone <= 1.77     )
{
   voltageone = 1.765;
  }
if       (voltageone >=       1.77    &&     voltageone <= 1.78     )
{
   voltageone = 1.775;
  }
if       (voltageone >=       1.78    &&     voltageone <= 1.79     )
{
   voltageone = 1.785;
  }
if       (voltageone >=       1.79    &&     voltageone <= 1.8      )
{
   voltageone = 1.795;
  }
if       (voltageone >=       1.8     &&     voltageone <= 1.81     )
{
   voltageone = 1.805;
```

```
  }
if      (voltageone >=      1.81    &&    voltageone <= 1.82    )
{
   voltageone = 1.815;
  }
if      (voltageone >=      1.82    &&    voltageone <= 1.83    )
{
   voltageone = 1.825;
  }
if      (voltageone >=      1.83    &&    voltageone <= 1.84    )
{
   voltageone = 1.835;
  }
if      (voltageone >=      1.84    &&    voltageone <= 1.85    )
{
   voltageone = 1.845;
  }
if      (voltageone >=      1.85    &&    voltageone <= 1.86    )
{
   voltageone = 1.855;
  }
if      (voltageone >=      1.86    &&    voltageone <= 1.87    )
{
   voltageone = 1.865;
  }
if      (voltageone >=      1.87    &&    voltageone <= 1.88    )
{
   voltageone = 1.875;
  }
if      (voltageone >=      1.88    &&    voltageone <= 1.89    )
{
   voltageone = 1.885;
  }
if      (voltageone >=      1.89    &&    voltageone <= 1.9     )
{
   voltageone = 1.895;
  }
if      (voltageone >=      1.9     &&    voltageone <= 1.91    )
{
   voltageone = 1.905;
  }
if      (voltageone >=      1.91    &&    voltageone <= 1.92    )
{
   voltageone = 1.915;
  }
if      (voltageone >=      1.92    &&    voltageone <= 1.93    )
```

```
{
   voltageone = 1.925;
  }
if       (voltageone >=       1.93    &&    voltageone <= 1.94    )
{
   voltageone = 1.935;
  }
if       (voltageone >=       1.94    &&    voltageone <= 1.95    )
{
   voltageone = 1.945;
  }
if       (voltageone >=       1.95    &&    voltageone <= 1.96    )
{
   voltageone = 1.955;
  }
if       (voltageone >=       1.96    &&    voltageone <= 1.97    )
{
   voltageone = 1.965;
  }
if       (voltageone >=       1.97    &&    voltageone <= 1.98    )
{
   voltageone = 1.975;
  }
if       (voltageone >=       1.98    &&    voltageone <= 1.99    )
{
   voltageone = 1.985;
  }
if       (voltageone >=       1.99    &&    voltageone <= 2       )
{
   voltageone = 1.995;
  }
if       (voltageone >=       2       &&    voltageone <= 2.01    )
{
   voltageone = 2.005;
  }
if       (voltageone >=       2.01    &&    voltageone <= 2.02    )
{
   voltageone = 2.015;
  }
if       (voltageone >=       2.02    &&    voltageone <= 2.03    )
{
   voltageone = 2.025;
  }
if       (voltageone >=       2.03    &&    voltageone <= 2.04    )
{
   voltageone = 2.035;
```

```
  }
if      (voltageone >=      2.04    &&    voltageone <= 2.05    )
{
   voltageone = 2.045;
  }
if      (voltageone >=      2.05    &&    voltageone <= 2.06    )
{
   voltageone = 2.055;
  }
if      (voltageone >=      2.06    &&    voltageone <= 2.07    )
{
   voltageone = 2.065;
  }
if      (voltageone >=      2.07    &&    voltageone <= 2.08    )
{
   voltageone = 2.075;
  }
if      (voltageone >=      2.08    &&    voltageone <= 2.09    )
{
   voltageone = 2.085;
  }
if      (voltageone >=      2.09    &&    voltageone <= 2.1     )
{
   voltageone = 2.095;
  }
if      (voltageone >=      2.1     &&    voltageone <= 2.11    )
{
   voltageone = 2.105;
  }
if      (voltageone >=      2.11    &&    voltageone <= 2.12    )
{
   voltageone = 2.115;
  }
if      (voltageone >=      2.12    &&    voltageone <= 2.13    )
{
   voltageone = 2.125;
  }
if      (voltageone >=      2.13    &&    voltageone <= 2.14    )
{
   voltageone = 2.135;
  }
if      (voltageone >=      2.14    &&    voltageone <= 2.15    )
{
   voltageone = 2.145;
  }
if      (voltageone >=      2.15    &&    voltageone <= 2.16    )
```

```
{
   voltageone = 2.155;
  }
if       (voltageone >=       2.16    &&    voltageone <= 2.17    )
{
   voltageone = 2.165;
  }
if       (voltageone >=       2.17    &&    voltageone <= 2.18    )
{
   voltageone = 2.175;
  }
if       (voltageone >=       2.18    &&    voltageone <= 2.19    )
{
   voltageone = 2.185;
  }
if       (voltageone >=       2.19    &&    voltageone <= 2.2     )
{
   voltageone = 2.195;
  }
if       (voltageone >=       2.2     &&    voltageone <= 2.21    )
{
   voltageone = 2.205;
  }
if       (voltageone >=       2.21    &&    voltageone <= 2.22    )
{
   voltageone = 2.215;
  }
if       (voltageone >=       2.22    &&    voltageone <= 2.23    )
{
   voltageone = 2.225;
  }
if       (voltageone >=       2.23    &&    voltageone <= 2.24    )
{
   voltageone = 2.235;
  }
if       (voltageone >=       2.24    &&    voltageone <= 2.25    )
{
   voltageone = 2.245;
  }
if       (voltageone >=       2.25    &&    voltageone <= 2.26    )
{
   voltageone = 2.255;
  }
if       (voltageone >=       2.26    &&    voltageone <= 2.27    )
{
   voltageone = 2.265;
```

```
  }
if      (voltageone >=      2.27    &&    voltageone <= 2.28    )
{
   voltageone = 2.275;
  }
if      (voltageone >=      2.28    &&    voltageone <= 2.29    )
{
   voltageone = 2.285;
  }
if      (voltageone >=      2.29    &&    voltageone <= 2.3     )
{
   voltageone = 2.295;
  }
if      (voltageone >=      2.3     &&    voltageone <= 2.31    )
{
   voltageone = 2.305;
  }
if      (voltageone >=      2.31    &&    voltageone <= 2.32    )
{
   voltageone = 2.315;
  }
if      (voltageone >=      2.32    &&    voltageone <= 2.33    )
{
   voltageone = 2.325;
  }
if      (voltageone >=      2.33    &&    voltageone <= 2.34    )
{
   voltageone = 2.335;
  }
if      (voltageone >=      2.34    &&    voltageone <= 2.35    )
{
   voltageone = 2.345;
  }
if      (voltageone >=      2.35    &&    voltageone <= 2.36    )
{
   voltageone = 2.355;
  }
if      (voltageone >=      2.36    &&    voltageone <= 2.37    )
{
   voltageone = 2.365;
  }
if      (voltageone >=      2.37    &&    voltageone <= 2.38    )
{
   voltageone = 2.375;
  }
if      (voltageone >=      2.38    &&    voltageone <= 2.39    )
```

```
{
   voltageone = 2.385;
  }
if       (voltageone >=       2.39    &&    voltageone <= 2.4      )
{
   voltageone = 2.395;
  }
if       (voltageone >=       2.4     &&    voltageone <= 2.41     )
{
   voltageone = 2.405;
  }
if       (voltageone >=       2.41    &&    voltageone <= 2.42     )
{
   voltageone = 2.415;
  }
if       (voltageone >=       2.42    &&    voltageone <= 2.43     )
{
   voltageone = 2.425;
  }
if       (voltageone >=       2.43    &&    voltageone <= 2.44     )
{
   voltageone = 2.435;
  }
if       (voltageone >=       2.44    &&    voltageone <= 2.45     )
{
   voltageone = 2.445;
  }
if       (voltageone >=       2.45    &&    voltageone <= 2.46     )
{
   voltageone = 2.455;
  }
if       (voltageone >=       2.46    &&    voltageone <= 2.47     )
{
   voltageone = 2.465;
  }
if       (voltageone >=       2.47    &&    voltageone <= 2.48     )
{
   voltageone = 2.475;
  }
if       (voltageone >=       2.48    &&    voltageone <= 2.49     )
{
   voltageone = 2.485;
  }
if       (voltageone >=       2.49    &&    voltageone <= 2.5      )
{
   voltageone = 2.495;
```

```
  }
if      (voltageone >=      2.5     &&      voltageone <= 2.51     )
{
   voltageone = 2.505;
  }
if      (voltageone >=      2.51    &&      voltageone <= 2.52     )
{
   voltageone = 2.515;
  }
if      (voltageone >=      2.52    &&      voltageone <= 2.53     )
{
   voltageone = 2.525;
  }
if      (voltageone >=      2.53    &&      voltageone <= 2.54     )
{
   voltageone = 2.535;
  }
if      (voltageone >=      2.54    &&      voltageone <= 2.55     )
{
   voltageone = 2.545;
  }
if      (voltageone >=      2.55    &&      voltageone <= 2.56     )
{
   voltageone = 2.555;
  }
if      (voltageone >=      2.56    &&      voltageone <= 2.57     )
{
   voltageone = 2.565;
  }
if      (voltageone >=      2.57    &&      voltageone <= 2.58     )
{
   voltageone = 2.575;
  }
if      (voltageone >=      2.58    &&      voltageone <= 2.59     )
{
   voltageone = 2.585;
  }
if      (voltageone >=      2.59    &&      voltageone <= 2.6      )
{
   voltageone = 2.595;
  }
if      (voltageone >=      2.6     &&      voltageone <= 2.61     )
{
   voltageone = 2.605;
  }
if      (voltageone >=      2.61    &&      voltageone <= 2.62     )
```

```
{
   voltageone = 2.615;
  }
if       (voltageone >=       2.62    &&    voltageone <= 2.63    )
{
   voltageone = 2.625;
  }
if       (voltageone >=       2.63    &&    voltageone <= 2.64    )
{
   voltageone = 2.635;
  }
if       (voltageone >=       2.64    &&    voltageone <= 2.65    )
{
   voltageone = 2.645;
  }
if       (voltageone >=       2.65    &&    voltageone <= 2.66    )
{
   voltageone = 2.655;
  }
if       (voltageone >=       2.66    &&    voltageone <= 2.67    )
{
   voltageone = 2.665;
  }
if       (voltageone >=       2.67    &&    voltageone <= 2.68    )
{
   voltageone = 2.675;
  }
if       (voltageone >=       2.68    &&    voltageone <= 2.69    )
{
   voltageone = 2.685;
  }
if       (voltageone >=       2.69    &&    voltageone <= 2.7     )
{
   voltageone = 2.695;
  }
if       (voltageone >=       2.7     &&    voltageone <= 2.71    )
{
   voltageone = 2.705;
  }

  if     (voltageone >=       2.71    &&    voltageone <= 2.72    )
  {
   voltageone = 2.715;
  }
if       (voltageone >=       2.72    &&    voltageone <= 2.73    )
{
```

```
   voltageone = 2.725;
  }
if       (voltageone >=       2.73    &&    voltageone <= 2.74    )
{
   voltageone = 2.735;
  }
if       (voltageone >=       2.74    &&    voltageone <= 2.75    )
{
   voltageone = 2.745;
  }
if       (voltageone >=       2.75    &&    voltageone <= 2.76    )
{
   voltageone = 2.755;
  }
if       (voltageone >=       2.76    &&    voltageone <= 2.77    )
{
   voltageone = 2.765;
  }
if       (voltageone >=       2.77    &&    voltageone <= 2.78    )
{
   voltageone = 2.775;
  }
if       (voltageone >=       2.78    &&    voltageone <= 2.79    )
{
   voltageone = 2.785;
  }
if       (voltageone >=       2.79    &&    voltageone <= 2.8     )
{
   voltageone = 2.795;
  }
if       (voltageone >=       2.8     &&    voltageone <= 2.81    )
{
   voltageone = 2.805;
  }
if       (voltageone >=       2.81    &&    voltageone <= 2.82    )
{
   voltageone = 2.815;
  }
if       (voltageone >=       2.82    &&    voltageone <= 2.83    )
{
   voltageone = 2.825;
  }
if       (voltageone >=       2.83    &&    voltageone <= 2.84    )
{
   voltageone = 2.835;
  }
```

```
if      (voltageone >=      2.84    &&    voltageone <= 2.85    )
{
   voltageone = 2.845;
 }
if      (voltageone >=      2.85    &&    voltageone <= 2.86    )
{
   voltageone = 2.855;
 }
if      (voltageone >=      2.86    &&    voltageone <= 2.87    )
{
   voltageone = 2.865;
 }
if      (voltageone >=      2.87    &&    voltageone <= 2.88    )
{
   voltageone = 2.875;
 }
if      (voltageone >=      2.88    &&    voltageone <= 2.89    )
{
   voltageone = 2.885;
 }
if      (voltageone >=      2.89    &&    voltageone <= 2.9     )
{
   voltageone = 2.895;
 }
if      (voltageone >=      2.9     &&    voltageone <= 2.91    )
{
   voltageone = 2.905;
 }
if      (voltageone >=      2.91    &&    voltageone <= 2.92    )
{
   voltageone = 2.915;
 }
if      (voltageone >=      2.92    &&    voltageone <= 2.93    )
{
   voltageone = 2.925;
 }
if      (voltageone >=      2.93    &&    voltageone <= 2.94    )
{
   voltageone = 2.935;
 }
if      (voltageone >=      2.94    &&    voltageone <= 2.95    )
{
   voltageone = 2.945;
 }
if      (voltageone >=      2.95    &&    voltageone <= 2.96    )
{
```

```
   voltageone = 2.955;
  }
if       (voltageone >=       2.96    &&    voltageone <= 2.97    )
{
   voltageone = 2.965;
  }
if       (voltageone >=       2.97    &&    voltageone <= 2.98    )
{
   voltageone = 2.975;
  }
if       (voltageone >=       2.98    &&    voltageone <= 2.99    )
{
   voltageone = 2.985;
  }
if       (voltageone >=       2.99    &&    voltageone <= 3       )
{
   voltageone = 2.995;
  }
if       (voltageone >=       3       &&    voltageone <= 3.01    )
{
   voltageone = 3.005;
  }
if       (voltageone >=       3.01    &&    voltageone <= 3.02    )
{
   voltageone = 3.015;
  }
if       (voltageone >=       3.02    &&    voltageone <= 3.03    )
{
   voltageone = 3.025;
  }
if       (voltageone >=       3.03    &&    voltageone <= 3.04    )
{
   voltageone = 3.035;
  }
if       (voltageone >=       3.04    &&    voltageone <= 3.05    )
{
   voltageone = 3.045;
  }
if       (voltageone >=       3.05    &&    voltageone <= 3.06    )
{
   voltageone = 3.055;
  }
if       (voltageone >=       3.06    &&    voltageone <= 3.07    )
{
   voltageone = 3.065;
  }
```

```
if      (voltageone >=      3.07    &&    voltageone <= 3.08    )
{
   voltageone = 3.075;
 }
if      (voltageone >=      3.08    &&    voltageone <= 3.09    )
{
   voltageone = 3.085;
 }
if      (voltageone >=      3.09    &&    voltageone <= 3.1     )
{
   voltageone = 3.095;
 }
if      (voltageone >=      3.1     &&    voltageone <= 3.11    )
{
   voltageone = 3.105;
 }
if      (voltageone >=      3.11    &&    voltageone <= 3.12    )
{
   voltageone = 3.115;
 }
if      (voltageone >=      3.12    &&    voltageone <= 3.13    )
{
   voltageone = 3.125;
 }
if      (voltageone >=      3.13    &&    voltageone <= 3.14    )
{
   voltageone = 3.135;
 }
if      (voltageone >=      3.14    &&    voltageone <= 3.15    )
{
   voltageone = 3.145;
 }
if      (voltageone >=      3.15    &&    voltageone <= 3.16    )
{
   voltageone = 3.155;
 }
if      (voltageone >=      3.16    &&    voltageone <= 3.17    )
{
   voltageone = 3.165;
 }
if      (voltageone >=      3.17    &&    voltageone <= 3.18    )
{
   voltageone = 3.175;
 }
if      (voltageone >=      3.18    &&    voltageone <= 3.19    )
{
```

```
   voltageone = 3.185;
  }
if      (voltageone >=      3.19    &&    voltageone <= 3.2     )
{
   voltageone = 3.195;
  }
if      (voltageone >=      3.2     &&    voltageone <= 3.21    )
{
   voltageone = 3.205;
  }
if      (voltageone >=      3.21    &&    voltageone <= 3.22    )
{
   voltageone = 3.215;
  }
if      (voltageone >=      3.22    &&    voltageone <= 3.23    )
{
   voltageone = 3.225;
  }
if      (voltageone >=      3.23    &&    voltageone <= 3.24    )
{
   voltageone = 3.235;
  }
if      (voltageone >=      3.24    &&    voltageone <= 3.25    )
{
   voltageone = 3.245;
  }
if      (voltageone >=      3.25    &&    voltageone <= 3.26    )
{
   voltageone = 3.255;
  }
if      (voltageone >=      3.26    &&    voltageone <= 3.27    )
{
   voltageone = 3.265;
  }
if      (voltageone >=      3.27    &&    voltageone <= 3.28    )
{
   voltageone = 3.275;
  }
if      (voltageone >=      3.28    &&    voltageone <= 3.29    )
{
   voltageone = 3.285;
  }
if      (voltageone >=      3.29    &&    voltageone <= 3.3     )
{
   voltageone = 3.295;
  }
```

```
if      (voltageone >=      3.3     &&     voltageone <= 3.31     )
{
   voltageone = 3.305;
  }
if      (voltageone >=      3.31    &&     voltageone <= 3.32     )
{
   voltageone = 3.315;
  }
if      (voltageone >=      3.32    &&     voltageone <= 3.33     )
{
   voltageone = 3.325;
  }
if      (voltageone >=      3.33    &&     voltageone <= 3.34     )
{
   voltageone = 3.335;
  }
if      (voltageone >=      3.34    &&     voltageone <= 3.35     )
{
   voltageone = 3.345;
  }
if      (voltageone >=      3.35    &&     voltageone <= 3.36     )
{
   voltageone = 3.355;
  }
if      (voltageone >=      3.36    &&     voltageone <= 3.37     )
{
   voltageone = 3.365;
  }
if      (voltageone >=      3.37    &&     voltageone <= 3.38     )
{
   voltageone = 3.375;
  }
if      (voltageone >=      3.38    &&     voltageone <= 3.39     )
{
   voltageone = 3.385;
  }

  if (voltageone >= 1.4)
/* we chose to have the value of voltage be greater than or equal to 1.4 because if the voltage is
1.4 or higher, it means that there is liquid in the bottle.  If it falls below that, that means there is
nothing on the device or the bottle is empty.  Therefore there will be no conversions and no
transmitting to excel */
  {
ml = ((voltageone - 1.63)/0.00345);

  // Conversions from mls to other units
```

```
  if (ml >= 0)     // mls has to be at least 0, we don't want negative numbers
  {
    ounces  = ml * 0.0338;

    cups = ounces * 0.125;


  // Sends the data to Excel
Serial.print("DATA, TIME,"); Serial.print(pounds); Serial.print(","); Serial.print(ounces);
Serial.print(","); Serial.print(cups); Serial.print(","); Serial.println(ml);


  }

  }

  delay(1000);   // delay in between reads for stability

}
```