Deliverable I

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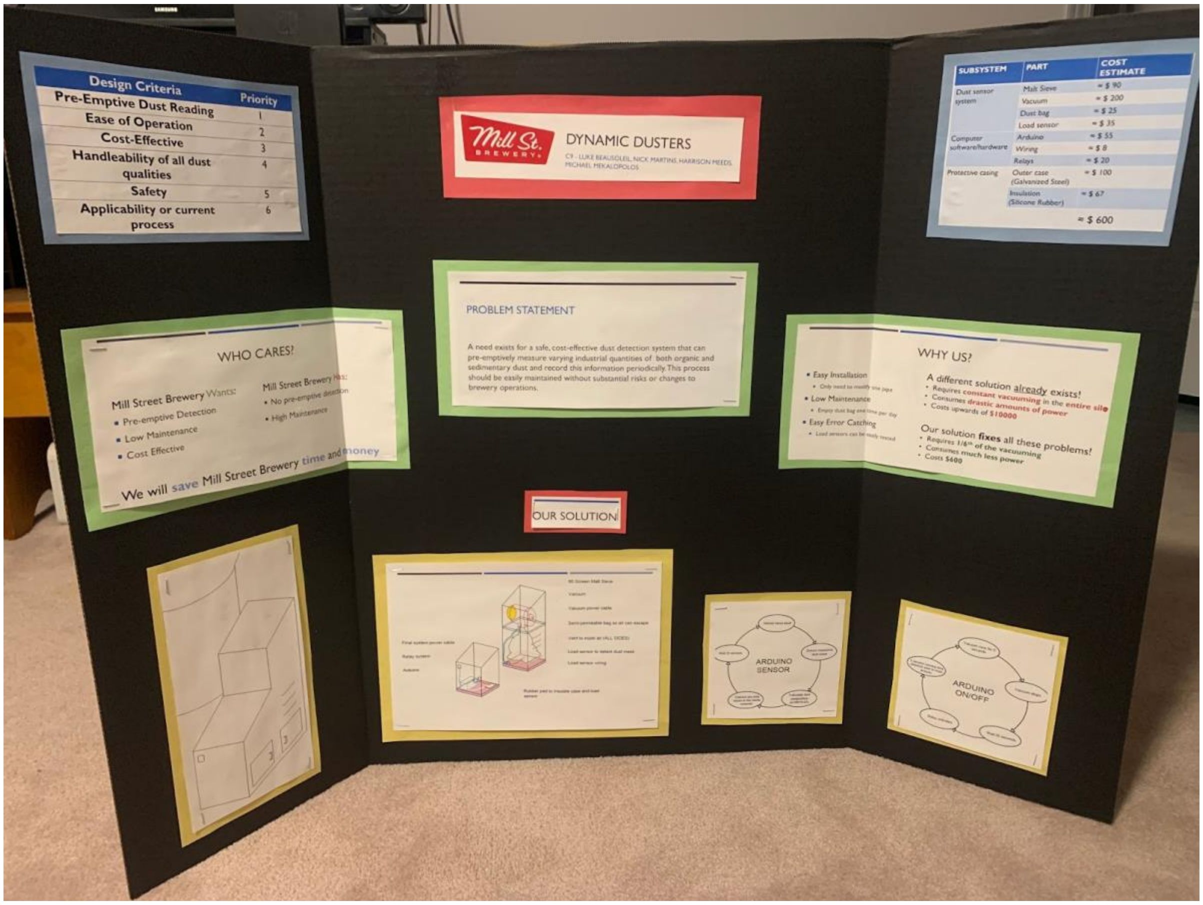
1. Two-line Description

A vacuum system that pulls a portion of dust out of a transfer pipe and measures the dust mass with a load sensor. An Arduino reads this mass and calculates the dust composition for pre-emptive dust handling.

2. Presentation Material



Design Criteria	Priority
Pre-Emptive Dust Reading	1
Ease of Operation	2
Cost-Effective	3
Handleability of all dust qualities	4
Safety	5
Applicability or current process	6

DYNAMIC DUSTERS

C9 - LUKE BEAUSOLEIL, NICK MARTINS, HARRISON MEEDS, MICHAEL MEKALOPOLOS

SUBSYSTEM	PART	COST ESTIMATE
Dust sensor system	Malt Sieve	≈ $ 90
	Vacuum	≈ $ 200
	Dust bag	≈ $ 25
	Load sensor	≈ $ 35
Computer software/hardware	Arduino	≈ $ 55
	Wiring	≈ $ 8
	Relays	≈ $ 20
Protective casing	Outer case (Galvanized Steel)	≈ $ 100
	Insulation (Silicone Rubber)	≈ $ 67
		≈ $ 600

WHO CARES?

Mill Street Brewery Wants:
- Pre-emptive Detection
- Low Maintenance
- Cost Effective

Mill Street Brewery Has:
- No pre-emptive detection
- High Maintenance

We will save Mill Street Brewery time and money

PROBLEM STATEMENT

A need exists for a safe, cost-effective dust detection system that can pre-emptively measure varying industrial quantities of both organic and sedimentary dust and record this information periodically. This process should be easily maintained without substantial risks or changes to brewery operations.

WHY US?

- Easy Installation
- Low Maintenance
- Easy Error Catching

A different solution already exists!
- Requires constant vacuuming in the entire silo
- Consumes drastic amounts of power
- Costs upwards of $10000

Our solution **fixes** all these problems!
- Requires 1/6th of the vacuuming
- Consumes much less power
- Costs $600

OUR SOLUTION

Figure 1. Design Day Poster Board

Note: The slides in part 2 of this deliverable were printed to make the poster board. However, the slides are not necessarily in the right order/orientation/etc. Therefore, they have no logical

2.1. Testing Data

Table 1. Vacuum System Test Results

Trial #	**Mixture Before Vacuuming**			**Mixture After Vacuuming**	**Flour Removed**	
	Kernels (g)	Flour (g)	Total (g)	Total Mass (g)	Mass (g)	% of Flour
1	130	10	140	138	2	20
2	130	9	139	136	2	22.22
3	128	6	134	133	1	16.67
Average						19.63

Table 2. Load Sensor Test Results

Trial	**Real Flour %**	**Measured Flour %**	**% Error**
1	7.69	7.32	4.81
2	6.15	6.38	3.74
3	3.85	3.70	3.90
Average			4.15

Table 3. Casing Materials' Specifications

Material	**Yield Strength (MPa)**	**Survives Snow ($4.17\text{x}10^{-4}$ MPa)**	**Survives Wind ($7.26\text{x}10^{-4}$ MPa)**	**Cost (\$/m^2)**
Galvanized Steel	520	Yes	Yes	28.58
Aluminium	270	Yes	Yes	41.23
Polyvinyl chloride (PVC)	55.2	Yes	Yes	53.77

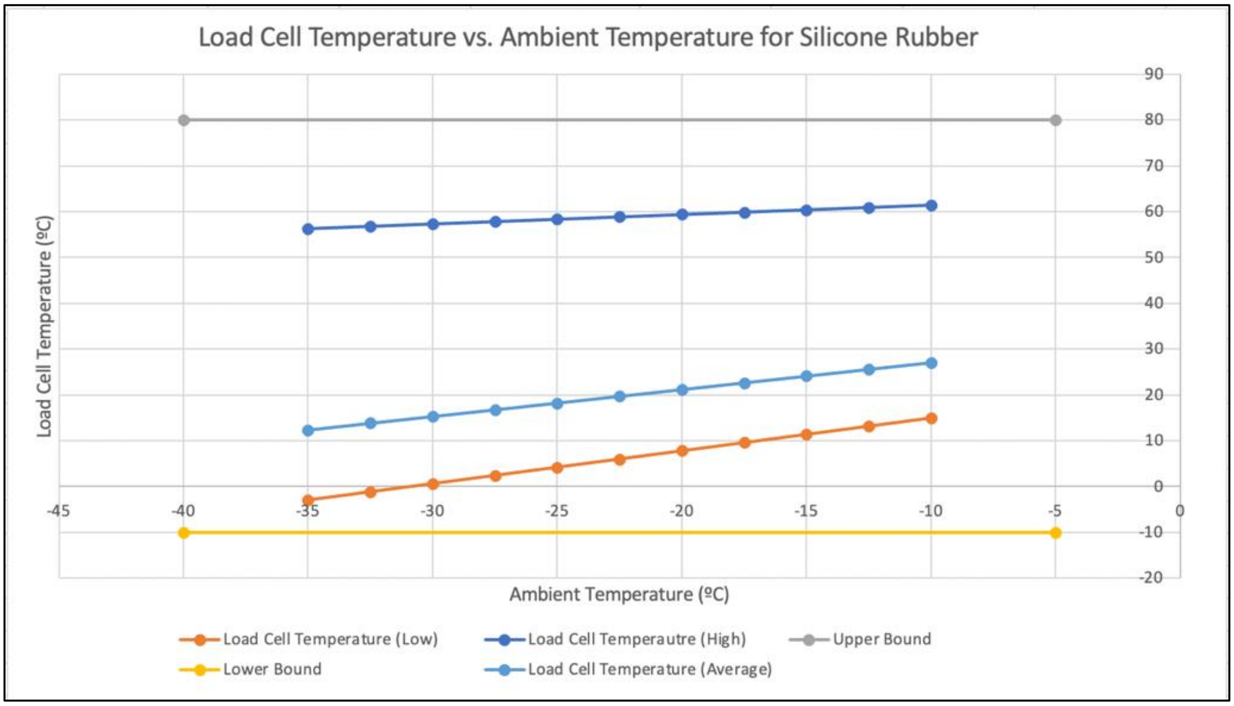


Figure 2. Load Cell Temperature vs. Ambient Temperature for Silicone Rubber

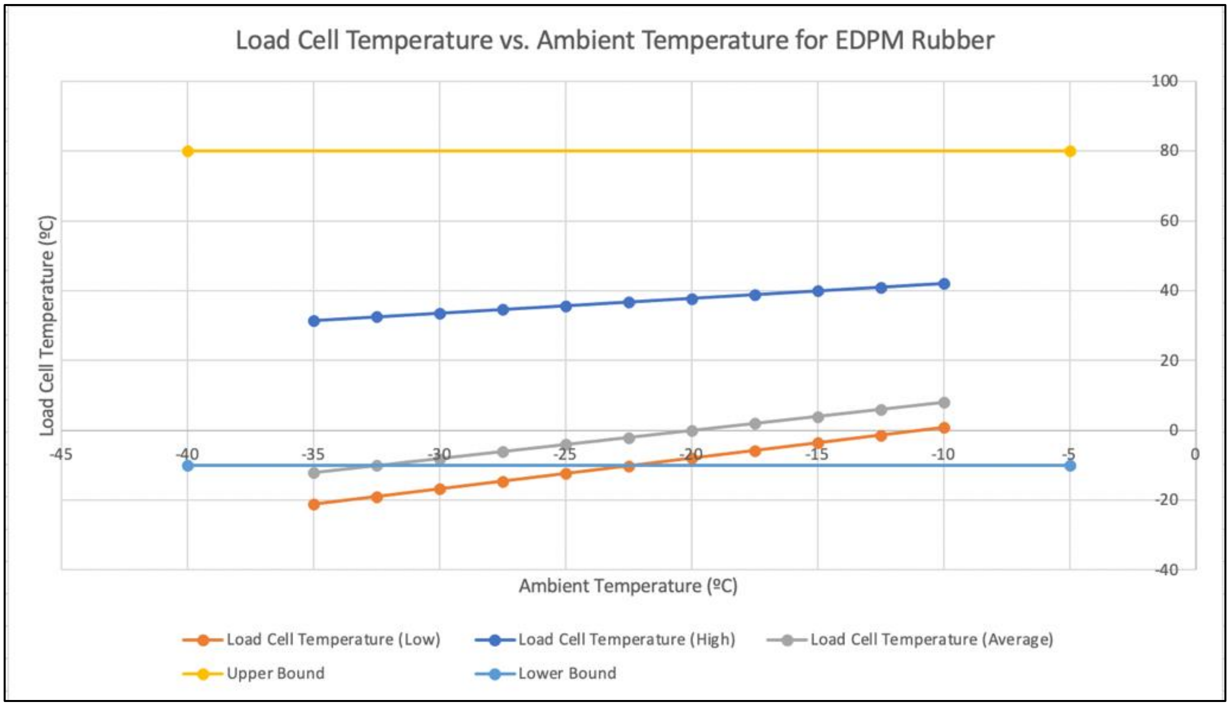


Figure 3. Load Cell Temperature vs. Ambient Temperature for EDPM Rubber

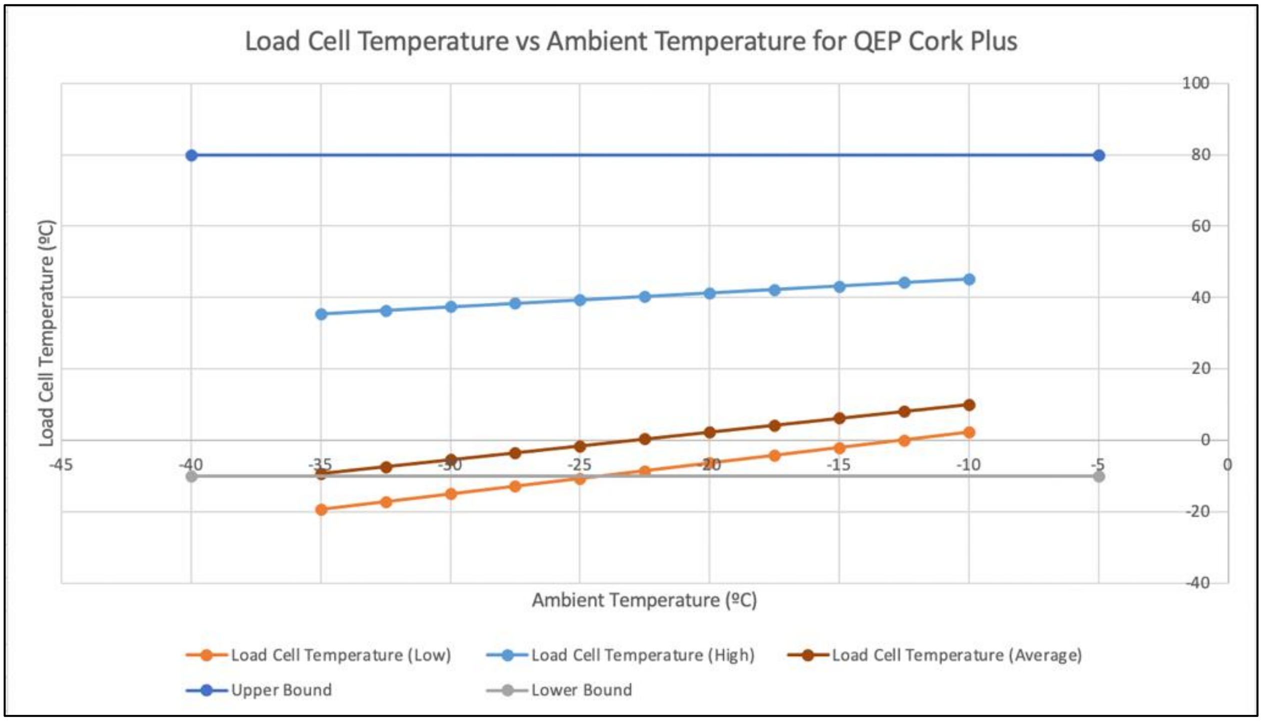
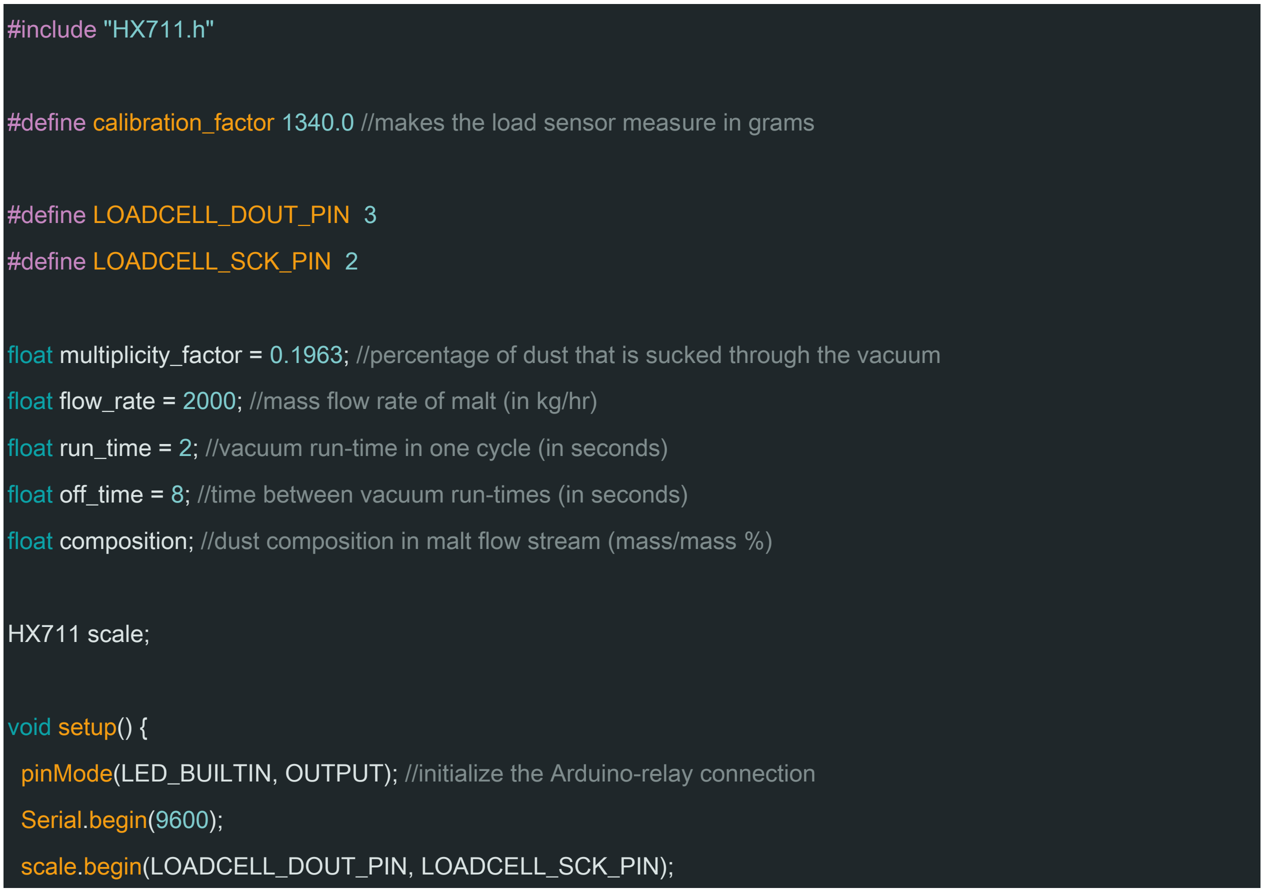
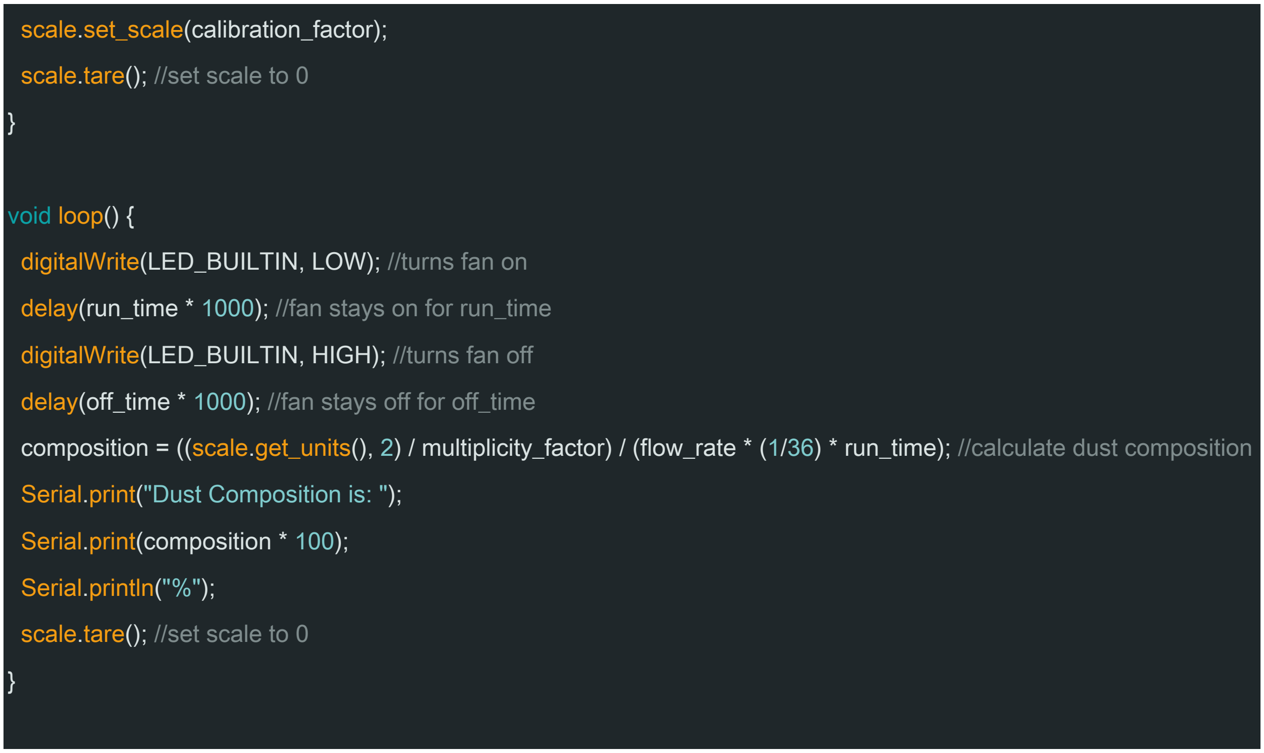


Figure 4. Load Cell Temperature vs. Ambient Temperature for QEP Cork Plus



```
#include "HX711.h"

#define calibration_factor 1340.0 //makes the load sensor measure in grams

#define LOADCELL_DOUT_PIN  3
#define LOADCELL_SCK_PIN  2

float multiplicity_factor = 0.1963; //percentage of dust that is sucked through the vacuum
float flow_rate = 2000; //mass flow rate of malt (in kg/hr)
float run_time = 2; //vacuum run-time in one cycle (in seconds)
float off_time = 8; //time between vacuum run-times (in seconds)
float composition; //dust composition in malt flow stream (mass/mass %)

HX711 scale;

void setup() {
  pinMode(LED_BUILTIN, OUTPUT); //initialize the Arduino-relay connection
  Serial.begin(9600);
  scale.begin(LOADCELL_DOUT_PIN, LOADCELL_SCK_PIN);
```



```
  scale.set_scale(calibration_factor);
  scale.tare(); //set scale to 0
}

void loop() {
  digitalWrite(LED_BUILTIN, LOW); //turns fan on
  delay(run_time * 1000); //fan stays on for run_time
  digitalWrite(LED_BUILTIN, HIGH); //turns fan off
  delay(off_time * 1000); //fan stays off for off_time
  composition = ((scale.get_units(), 2) / multiplicity_factor) / (flow_rate * (1/36) * run_time); //calculate dust composition
  Serial.print("Dust Composition is: ");
  Serial.print(composition * 100);
  Serial.println("%");
  scale.tare(); //set scale to 0
}
```

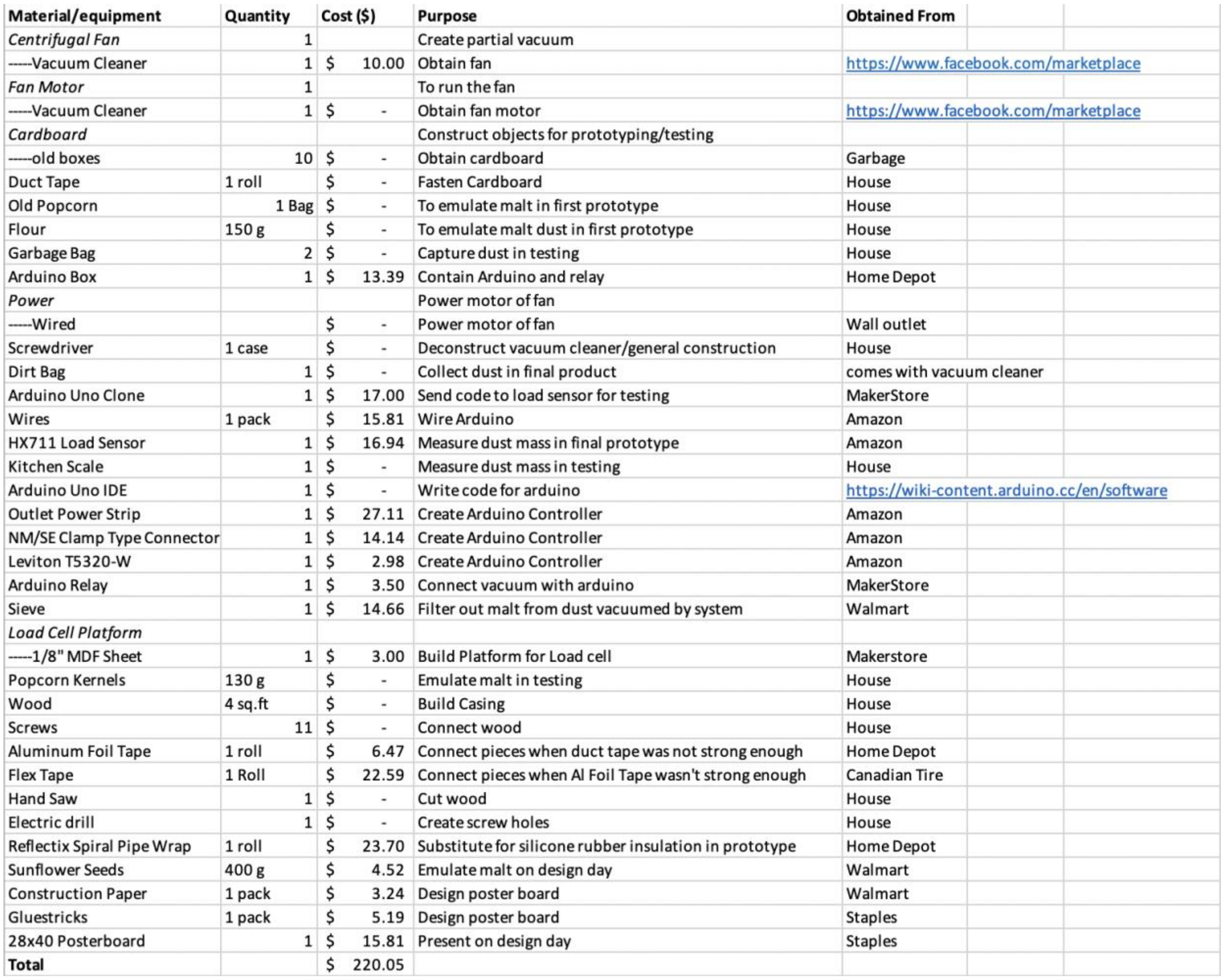
Figure 5. Code to Control Vacuum and Load Sensor

3. Updated Bill of Materials

Table 4 provides a list of all materials and equipment used in the design process for this project, their quantity, cost, purpose, and place from which they are obtained.

However, if this design were made into a real product, the bill of materials would need to be updated to reflect all the additional materials and equipment needed.

Table 4. Bill of Materials



Material/equipment	**Quantity**	**Cost ($)**	**Purpose**	**Obtained From**
Centrifugal Fan	1		Create partial vacuum	
-----Vacuum Cleaner	1	$ 10.00	Obtain fan	https://www.facebook.com/marketplace
Fan Motor	1		To run the fan	
-----Vacuum Cleaner	1	$ -	Obtain fan motor	https://www.facebook.com/marketplace
Cardboard			Construct objects for prototyping/testing	
-----old boxes	10	$ -	Obtain cardboard	Garbage
Duct Tape	1 roll	$ -	Fasten Cardboard	House
Old Popcorn	1 Bag	$ -	To emulate malt in first prototype	House
Flour	150 g	$ -	To emulate malt dust in first prototype	House
Garbage Bag	2	$ -	Capture dust in testing	House
Arduino Box	1	$ 13.39	Contain Arduino and relay	Home Depot
Power			Power motor of fan	
-----Wired		$ -	Power motor of fan	Wall outlet
Screwdriver	1 case	$ -	Deconstruct vacuum cleaner/general construction	House
Dirt Bag	1	$ -	Collect dust in final product	comes with vacuum cleaner
Arduino Uno Clone	1	$ 17.00	Send code to load sensor for testing	MakerStore
Wires	1 pack	$ 15.81	Wire Arduino	Amazon
HX711 Load Sensor	1	$ 16.94	Measure dust mass in final prototype	Amazon
Kitchen Scale	1	$ -	Measure dust mass in testing	House
Arduino Uno IDE	1	$ -	Write code for arduino	https://wiki-content.arduino.cc/en/software
Outlet Power Strip	1	$ 27.11	Create Arduino Controller	Amazon
NM/SE Clamp Type Connector	1	$ 14.14	Create Arduino Controller	Amazon
Leviton T5320-W	1	$ 2.98	Create Arduino Controller	Amazon
Arduino Relay	1	$ 3.50	Connect vacuum with arduino	MakerStore
Sieve	1	$ 14.66	Filter out malt from dust vacuumed by system	Walmart
Load Cell Platform				
-----1/8" MDF Sheet	1	$ 3.00	Build Platform for Load cell	Makerstore
Popcorn Kernels	130 g	$ -	Emulate malt in testing	House
Wood	4 sq.ft	$ -	Build Casing	House
Screws	11	$ -	Connect wood	House
Aluminum Foil Tape	1 roll	$ 6.47	Connect pieces when duct tape was not strong enough	Home Depot
Flex Tape	1 Roll	$ 22.59	Connect pieces when Al Foil Tape wasn't strong enough	Canadian Tire
Hand Saw	1	$ -	Cut wood	House
Electric drill	1	$ -	Create screw holes	House
Reflectix Spiral Pipe Wrap	1 roll	$ 23.70	Substitute for silicone rubber insulation in prototype	Home Depot
Sunflower Seeds	400 g	$ 4.52	Emulate malt on design day	Walmart
Construction Paper	1 pack	$ 3.24	Design poster board	Walmart
Gluestricks	1 pack	$ 5.19	Design poster board	Staples
28x40 Posterboard	1	$ 15.81	Present on design day	Staples
Total		$ 220.05		

4. Task Plan Update

https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=dPNijeK1dBKW2exZ3PnDYtKZlhB8T2zF%7CIE2DSNZVHA2DELSTGIYA