Portland State University
Group 4
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Background

Solution

Project We wanted to create a product that would safely store filament in a way that prevent exposure to moisture. Warnings for high humidity and low filament.

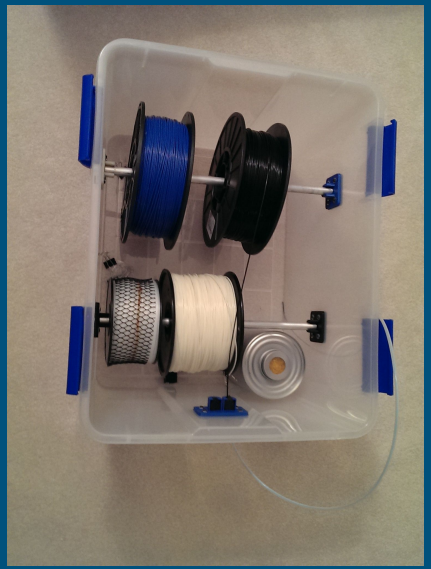
Importance Keeping filament unexposed to moisture will preserve the quality of the filament, therefore maintaining the quality of the print job and success rate. The product will also let the user know how much filament is remaining so they are not risking the chances of running out of filament mid print. This product is crucial to successful print jobs.

Objective

Filament is often kept unstored leaving exposure to moisture. Printers tell you how much you've printed but not how much filament is left in a spool. This product fixes both of these issues to increase the success and quality of a print job.

Our goal is to create a working prototype to pair with a 3D printer.

Alternatives



Requirements

Functionality

- System must detect humidity within the container and alert the user if humidity is too high
- System must measure the length of the filament and alert the user if the filament is too low
- System must have an interface so they can get the readings from the container
- The container must be sealed in order to reduce humidity

Requirements

Performance

- The weight measurement accuracy must be within 1 gram at all times
- The humidity sensor accuracy must be within 5% at all times
- The container must be able to store at least one spool of filament
- Information must be visible within 5 seconds when prompted

Approach

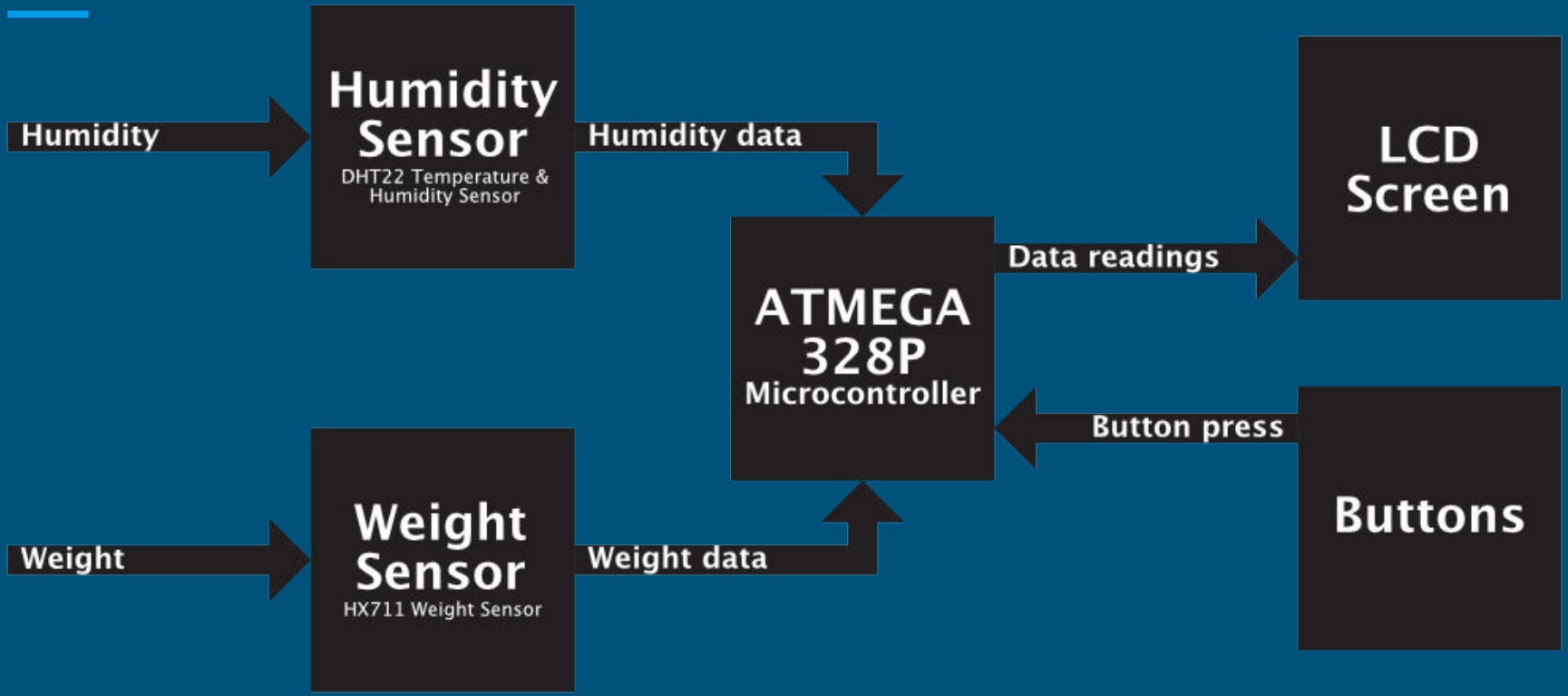
-Wanted to be cost effective

-Not take up a lot of space

-Accurate measurements and calculations

Design: Hardware

Black Box


Humidity
Humidity Sensor
DHT22 Temperature & Humidity Sensor
Humidity data
LCD Screen
Data readings
ATMEGA 328P Microcontroller
Button press
Buttons
Weight
Weight Sensor
HX711 Weight Sensor
Weight data

Event Table

EVENT	TRIGGER	PROCESS	SOURCE
Display readings	Button press	Data read	User
High humidity alert	Humidity readings	Display alert on LCD screen	System
Low filament warning	Remaining length reading	Display alert on LCD screen	System

Hardware

1. Load cell - weight sensor

- To measure weight of filament spool
- Load cell is a transducer that translates force/ pressure into electric signal.
- Bar Strain gauges: Two wired organized wires where resistance changes upon stretching/ compressing
- Force sensed by deformation of strain gauge(s)
- Bar strain gauge load cell (Z-shape) (provides torque for easier and accurate measurement)

Hardware

2. HX711 - Load cell Amplifier breakout board

- Load cell amplifier to read load cells to measure weight.
- Reads in small change in resistance and we can measure accurate weight with some calibration.
- Wheatstone bridge configuration used by load cell to connect to HX711
- Load cell has 4 strain gauges hooked up in wheatstone bridge formation (takes small change in resistance and make it more measurable)

Hardware

3. DHT22 - Humidity Sensor

- Low cost temperature and humidity sensor
- Uses capacitive humidity sensor to measure surrounding air
- Use pullup resistor from data pin to Vcc.

Hardware

4. LCD

- LCD Shield Kit w/ 16x2 Character Display
- I2C communication uses only 2 pins to connect with microcontroller
- 5 keypad buttons built-in the LCD
- Blue and White colors
- Backlight

Hardware

5. ATMega328P-PU - Microcontroller and SMD components

- Low cost microcontroller
- Similar to Arduino Uno - used for Development
- 8 bit AVR, 32 ch, 23 GPIO
- External 16 MHz Resonator with Built in Capacitor
- 100nF SMD Capacitor in 805 packaging
- LM340S Line 5v Voltage Regulator
- 4 pin SMD connector and ribbon cables

Design: Software

Software and Misc.

C - Language using Arduino

- Humidity and LCD libraries were downloaded from purchaser Adafruit.
- HX711 library was downloaded from github after finding one that worked
- Combined the examples together to form our code

Misc

- ¼ in. Acrylic sheets for support and durability
- 4xAA battery holder to provide long life

Implementation

Components

-**Humidity Sensor:** Analog to digital humidity and temperature sensor

-**Weight Sensor:** Weighs the spool

-**Microcontroller:** Controls the circuit

-**LCD Display:** Displays readings and menu

-**Acrylic:** The container

-**Silica beads:** Used to maintain low humidity levels

-**Plexiglass:** Sheets put together to make shell

Bill of Materials

Part	Quantity	Price (including shipping)
Microprocessor	1	$5.00
Humidity Sensor	1	$7.00
Blue and White LCD kit	1	$25.00
4xAA Battery Pack	1	$2.92
HX711 Board	1	$2.93
Plexiglass sheets ($9 ea)	3	$27.00
Misc hardware (i.e. screws, hinges, etc)	1	$10.00
		Total: $79.85

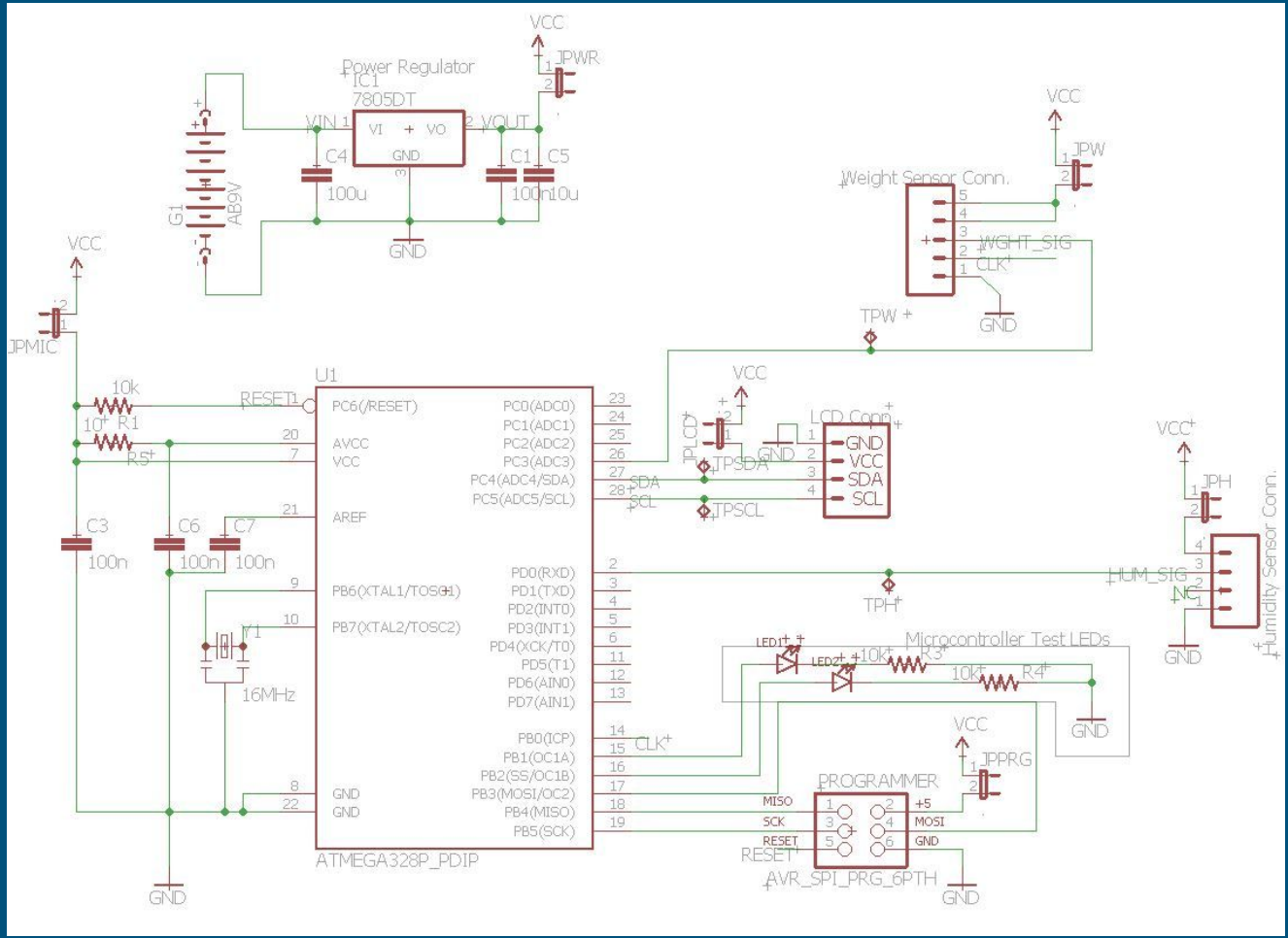
Tools Used

- Arduino used for Development
- Eagle CAD used for schematic and board layout
- Laser cutter for plexiglass
- Drill press for screw holes

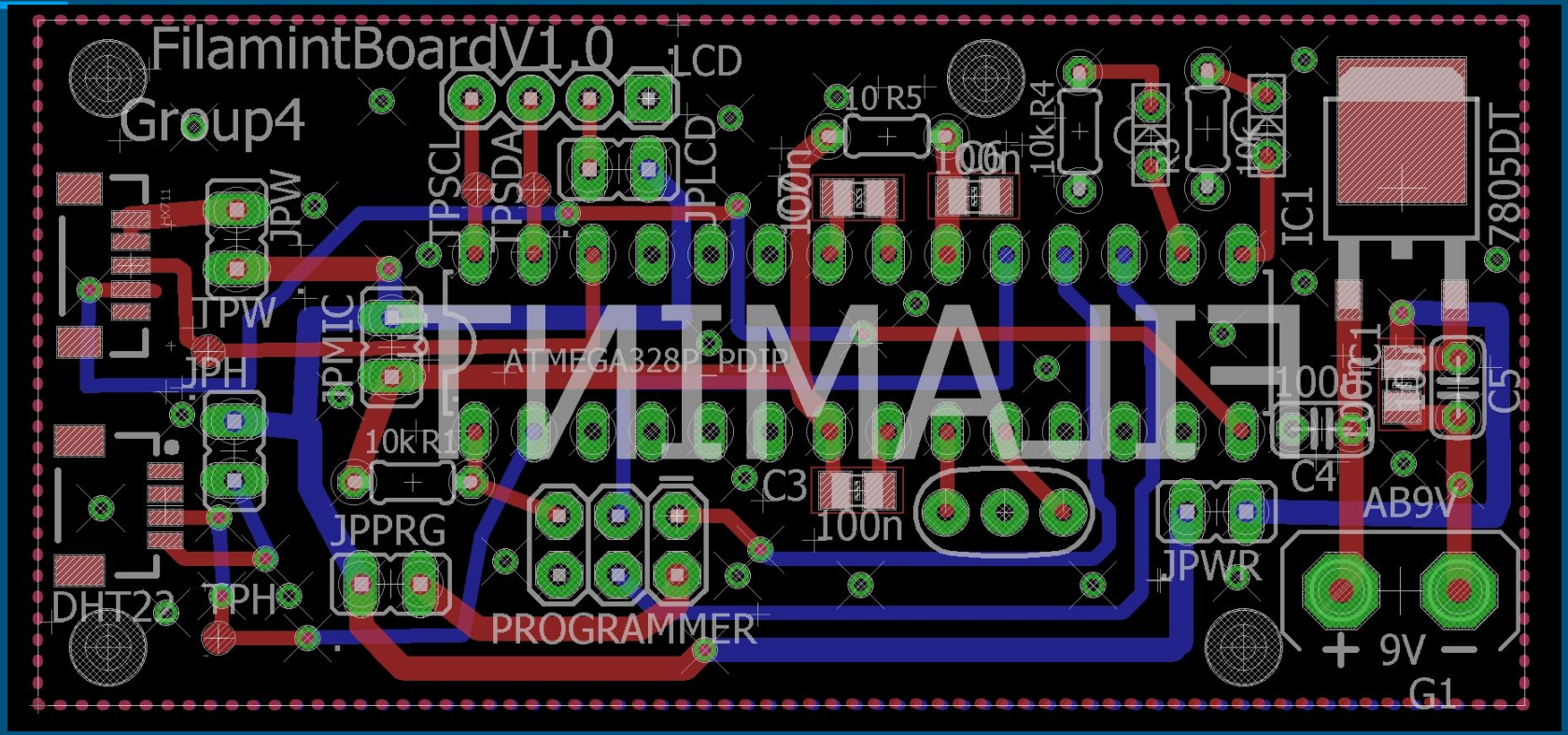
Test Cases

Test Case Link

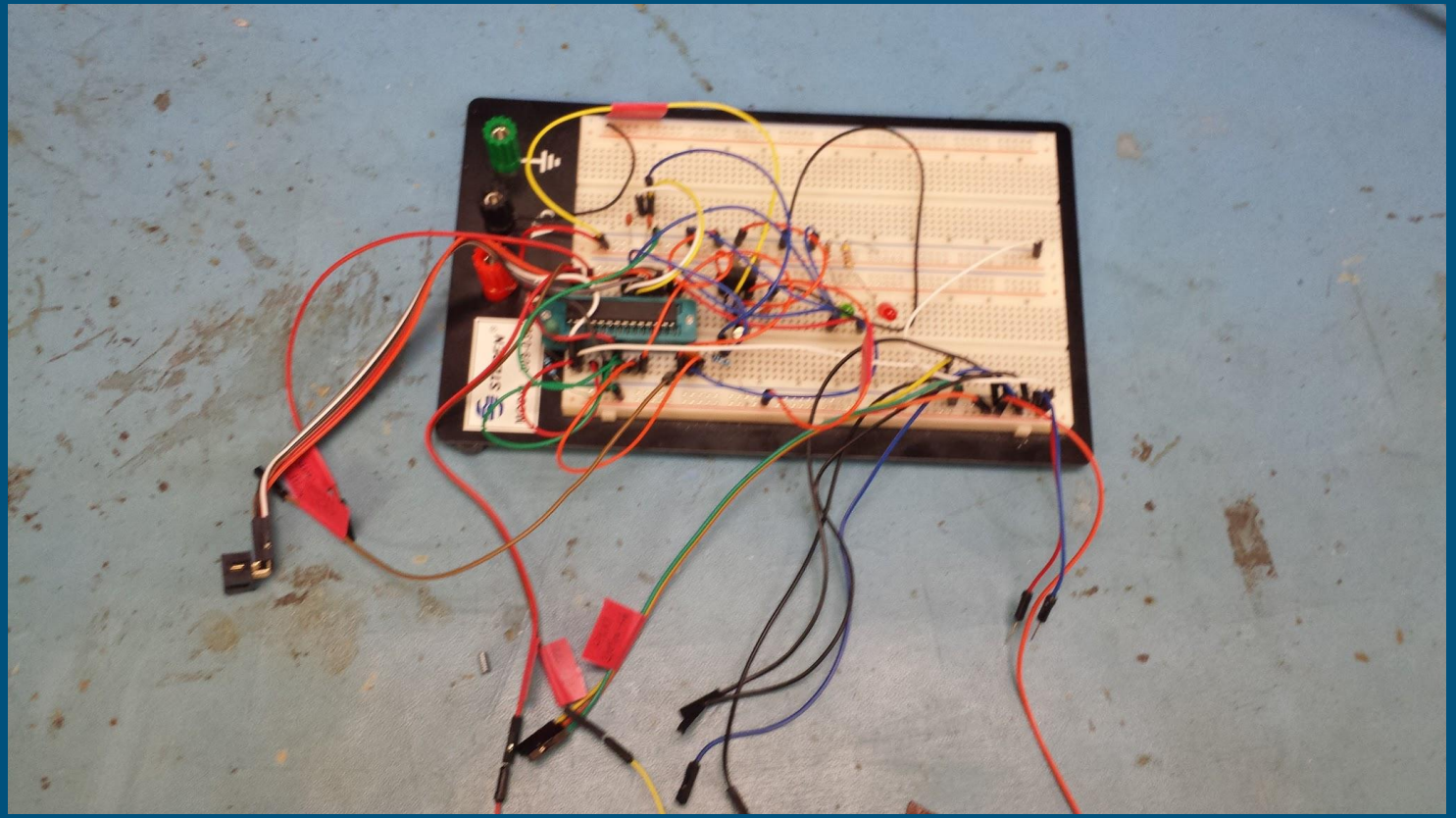
Schematic


Power Regulator
IC1
7805DT
VIN
VOUT
VI
VO
GND
C4
100u
C1
C5
100n10u
G1
ABW
VCC
JPWR
JPMIC
10k
R1
R5
U1
RESET
PC6(/RESET)
AVCC
VCC
AREF
PB6(XTAL1/TOSC1)
PB7(XTAL2/TOSC2)
GND
GND
PC0(ADC0)
PC1(ADC1)
PC2(ADC2)
PC3(ADC3)
PC4(ADC4/SDA)
PC5(ADC5/SCL)
PD0(RXD)
PD1(TXD)
PD2(INT0)
PD3(INT1)
PD4(XCK/T0)
PD5(T1)
PD6(AIN0)
PD7(AIN1)
PB0(ICP)
PB1(OC1A)
PB2(SS/OC1B)
PB3(MOSI/OC2)
PB4(MISO)
PB5(SCK)
ATMEGA328P_PDIP
C3
100n
C6
100n
C7
100n
Y1
16MHz
GND
Weight Sensor Conn.
JPW
WGHT_SIG
CLK
TPW
GND
JPLCD
TPSDA
TPSCL
LCD Conn
GND
VCC
SDA
SCL
SDA
SCL
CLK
JPH
TPH
HUM_SIG
NC
GND
Humidity Sensor Conn.
Microcontroller Test LEDs
LED1
LED2
10k
R3
10k
R4
GND
JPPRG
PROGRAMMER
MISO
SCK
RESET
+5
MOSI
GND
RESET
AVR_SPI_PRG_6PTH
GND

Board Layout



Prototype Board



Code

-Mass to Length conversion equation

-User Interface menu

-Displays and warns of high levels of humidity and low filament length

Code

- Github

IP and Prior Work

Referenced Work

- Used purchaser’s Libraries, example code and tutorials
  - LCD - Adafruit
  - Humidity - Adafruit
  - Weight - open source code from github user bogde

Testing

Strategy for Testing

- Solder board and parts together
- Upload code to board
- Debug

Results

What worked?

- Team meetings - accomplished a lot together in a short amount of time
- Google Drive to simultaneously work on documents
- GitHub to share code, create helpful pages, and revision control
- Locker with easy to remember combo “MINT” to keep all items at school
- Google Hangouts to create a dedicated group chat with all members this helped with status reports, questions, tips, notes, accountability
- LID and capstone lab tools i.e. laser cutter, drill press, crimper, dremel, etc.
- Extra parts purchased (we got some bad parts and slow shipping)

What didn’t work?

- Example codes - found out some example codes were outdated
- SMD connectors and ribbon cables are difficult to work with
- Group decisions on small items took longer than expected
- Learning curve was long for new tools i.e. github, eagle cad, arduino, atmel_studio, SMD soldering, LID tools-laser cutter, reflow oven

Individual Contributions

Colleen: coding, laser cutting, assembly, calculations/conversions, filament

David: construction, assembly, coding, debugging, EagleCAD design

Nettaly: debugging, coding, design, circuit analysis

Srijana: board layout, assembly, coding, laser cut, documentation

Lessons Learned

-What did each member learn

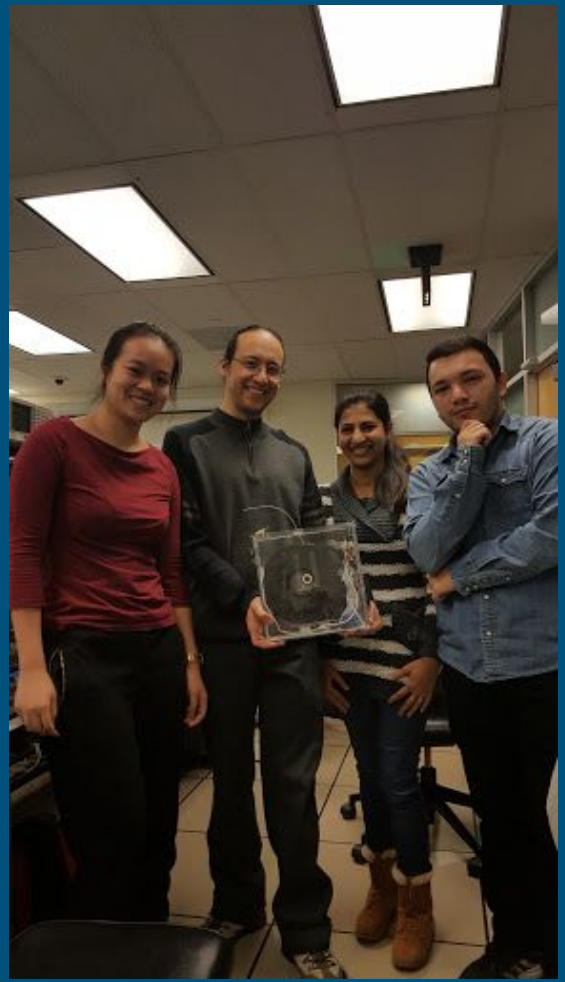
-what would we do differently

- More peer reviews
- Dedicated roles with backup
- More communication

-If we had more time…

- Better menu

-biggest mistake



Live demonstration!!

Thank you!