



BBQ Bonanza

PHYS 351.01

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“Also reason why we were late in Dr.D’s class”

Overview

1. BBQ is...
 - a. Difficult and Laborious to Control
 - b. Requires experience for consistency
 - c. Expensive!!!
2. Simplify the process
 - a. Make Cooking easier
 - b. Get Quality BBQ





Project Goal

Prototype a temperature sensor system that can analyse the relationship between a conventional smoker's operating temperature and its level of ventilation.



Criteria

- Our project tests our ability to integrate gathered data.
- Implement our analysis and measurements into software that can be used to predict a real world outcome.
- Our project will incorporate skills in programming to analyze and interpret data over a large period of time, and project this data to find a predictable outcome.

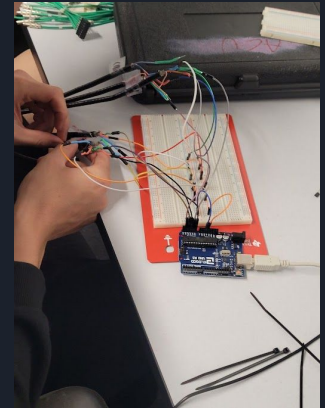
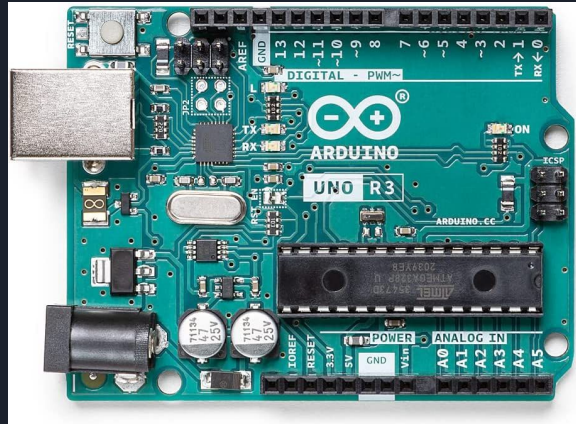
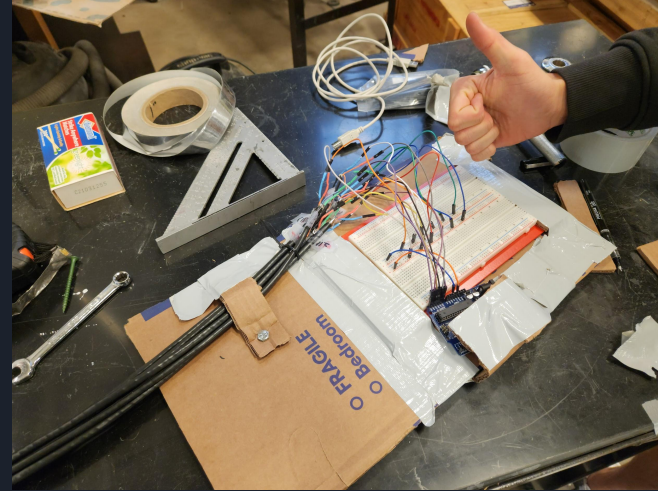


Methods

- Mount numerous temperature sensors inside smoker at different locations.
 - Levels of ventilation are recorded for given temperatures / rates of temperature increase.
- Interpretation of this data to find and plot the relationship between temperature and ventilation.
- Use interpolation / a fitting function to project necessary ventilation changes to achieve the target temperature.

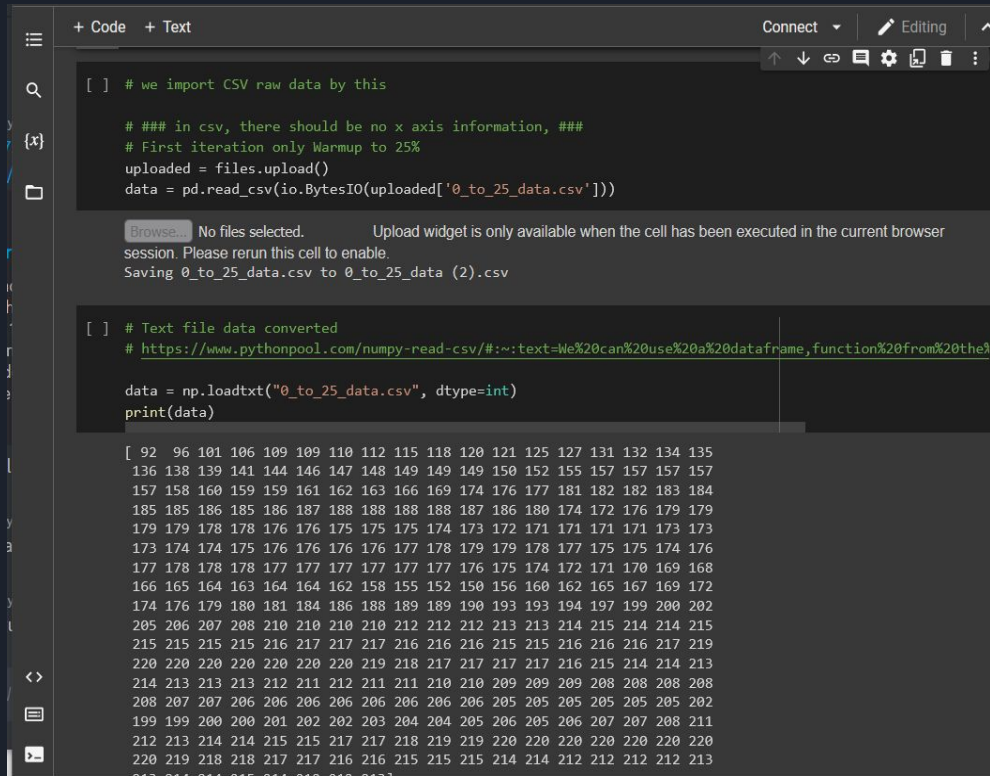
Setup: Hardware

- Temperature Sensor (TMP 36)
 - Temperature Range: -40F to 302F
- World Stiffest Cable
- Connecting Wire
- Bread Board
- Arduino Board (UNO REV3)



Setup: Software

- Find average values for peak temperature at ventilation levels 25%, 50%, 75%, 100%
- Fit a function to these values
- Use this function to determine the temperature for any given percentage of ventilation.



```
+ Code + Text
Connect Editing

[ ] # we import CSV raw data by this

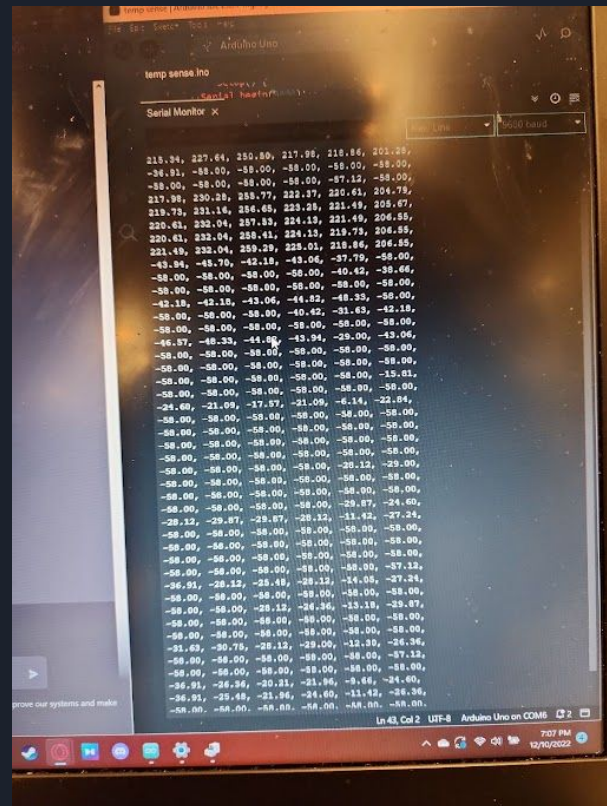
### in csv, there should be no x axis information, ###
# First iteration only Warmup to 25%
uploaded = files.upload()
data = pd.read_csv(io.BytesIO(uploaded['0_to_25_data.csv']))

Browse... No files selected. Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.
Saving 0_to_25_data.csv to 0_to_25_data (2).csv

[ ] # Text file data converted
# https://www.pythonpool.com/numpy-read-csv/#:~:text=We%20can%20use%20a%20dataframe,function%20from%20the%20numpy module
data = np.loadtxt("0_to_25_data.csv", dtype=int)
print(data)

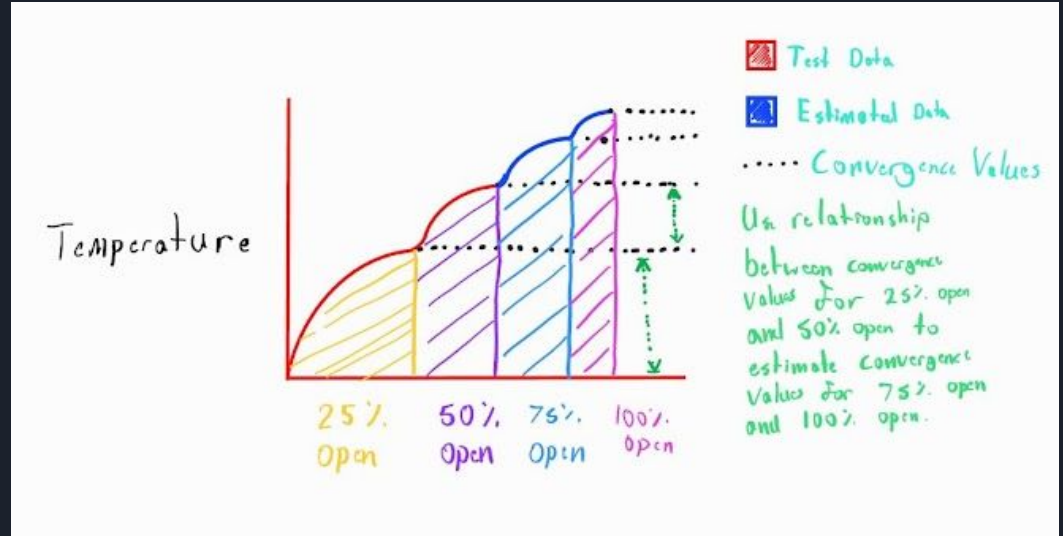
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```


ISSUES!!?!?!?



Solution

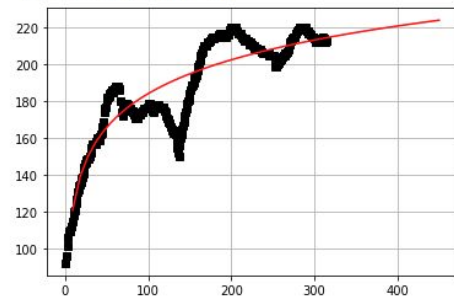
- Extrapolate Gathered data to full data range.
 - Data gathered from start up to 50% open.
- Plotted fully, data should follow a piecewise pattern, with each piece following a logarithmic curve.
- Convergence value for each logarithmic curve is our average temperature for each ventilation level.
- We must find the estimated convergence values for 75% open and 100% open.



▶ #Extrapolate by large amount to find convergence value

```
x_fit = np.linspace(0,450)
plt.plot(t, data, 'ks', label = 'data')
plt.plot(x_fit, fitfun(x_fit,*popt), '-r', label = 'cubic')
plt.grid()
```

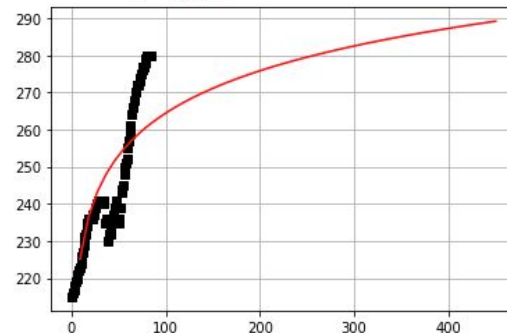
↳ <ipython-input-54-45e7cc951432>:6: RuntimeWarning: divide by zero encountered in log
return a*np.log(x) + b



▶ fitfun(450, popt[0], popt[1])

224.14763436859883

<ipython-input-68-ef09e9b7ecd0>:6: RuntimeWarning: divide by zero encountered in log
return a*np.log(x) + b



fitfun(450, popt[0], popt[1])

289.16958397559455

Temperature increase between ventilation levels seems to degrade by 50% for each 1/4 increase in ventilation:

50% open Peak temperature is 289 Degrees, 25% open Peak temperature is 224 Degrees, Starting temperature is 94 Degrees:

$$224 - 94 = 130 \text{ degree increase}$$

$$289 - 224 = 65 \text{ degree increase}$$

Therefore, we can assume that the increase in temperature at 75% ventilation should be approximately:

$$289 + \frac{65}{2} = 321.5 \text{ Degrees}$$

Subsequently we can determine the temperature at 100% to be approximately:

$$321.5 + \frac{32.5}{2} = 354 \text{ Degrees}$$

We will then fit a curve to these four peak temperatures to plot the relationship between temperature and ventilation.

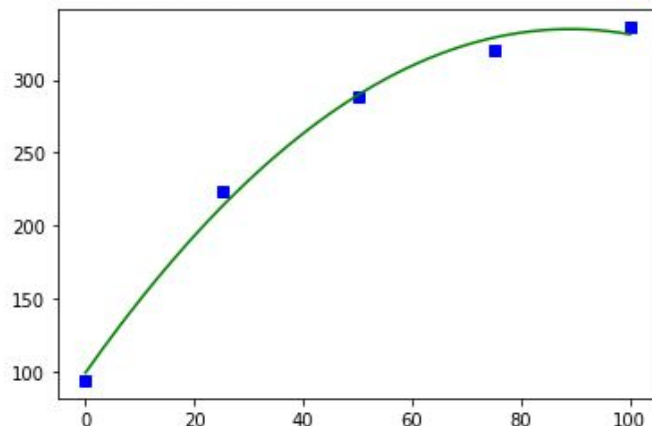
```
xdata = np.array([0, 25, 50, 75, 100])
ydata = np.array([94, 224, 288, 320, 336])
p = np.polyfit(xdata,ydata,2)

# evaluate the polynomial for a given x value
x = 79.2
y = np.polyval(p, x)
print(y)

x = np.linspace(0,100)
y = np.polyval(p, x)

plt.plot(xdata,ydata,'bs')
plt.plot(x,y,'g-')
plt.show()
```

331.95126857142856





Shortcomings

- Sensor system is fried
 - Can no longer definitively verify temperature estimations
- Large margin of error
 - Outdoor temperature can affect results by a large margin.
- Unable to verify results with actual BBQ
 - Time frame pushed significantly due to bad weather conditions. This negatively affected our schedule. Due to time restrictions, plans for actual BBQ is postponed.