LAB 1
CHARACTERIZING THE ATMOSPHERE

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OBJECTIVE AND EXPERIMENT

- To determine the accuracy and precision of smartphone pressure sensors using Phyphox, and determine the relationship between atmospheric pressure and altitude
- We collected our data in the stairwell of Planetary Hall by placing our phones on the floor on each level
- We all used iPhones with Bosch barometers with a sample rate of 1 Hz

SENSOR CHARACTERIZATION

The accuracy and precision of the barometers were measured by leaving them on the table inside.

This will help us determine the accuracy and precision of the barometer

SENSOR CHARACTERIZATION

A relative accuracy for everyone was calculated by $|\mu_{group} - \mu_{ind}|$ where $\mu_{group} = \frac{1}{4}\sum\mu_{ind}$.

The relative accuracy shows how close a person's sensor is to an agreeable group value.

The low standard deviation values confirm that the internal "noise" or oscillation of the sensors was minimal during the 13-second collection window.

All sensors are within approximately 0.06 hPa of the group mean, indicating high precision from the manufacturer calibration between different iPhone models (13-16).

Member	Mean Pressure (hPa)	Standard Deviation (hPa)	Relative Accuracy (hPa)
Daksh	1012.281	0.0017	**0.058**
Clarisse	1012.285	0.004	**0.062**
Tim	1012.277	0.007	**0.054**
Joel	1012.281	0.0017	**0.058**

SENSOR CHARACTERIZATION

The table here is showing the precision of the sensors by taking the absolute difference of the standard deviations of each person compared to another. The

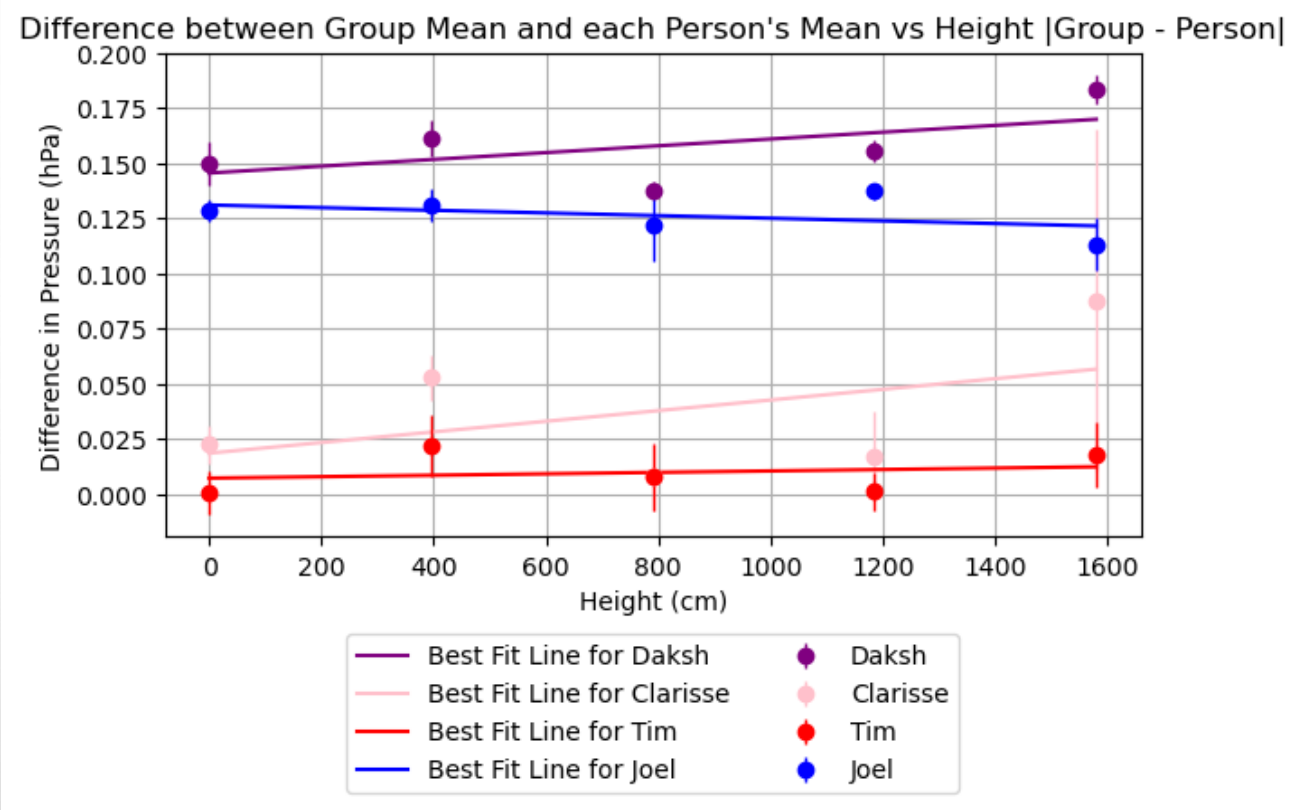
The reported precision concludes that random fluctuations are negligible

Device Comparison	Calculated Difference (hPa)	Reported Precision (hPa)
Daksh vs. Clarisse	0.0055	0.006
Daksh vs. Tim	0.0054	0.005
Daksh vs. Joel	0	0
Clarisse vs. Tim	0.0104	0.01
Clarisse vs. Joel	0.0055	0.006
Tim vs. Joel	0.0054	0.005

MODELING THE RELATIONSHIP BETWEEN PRESSURE VS HEIGHT

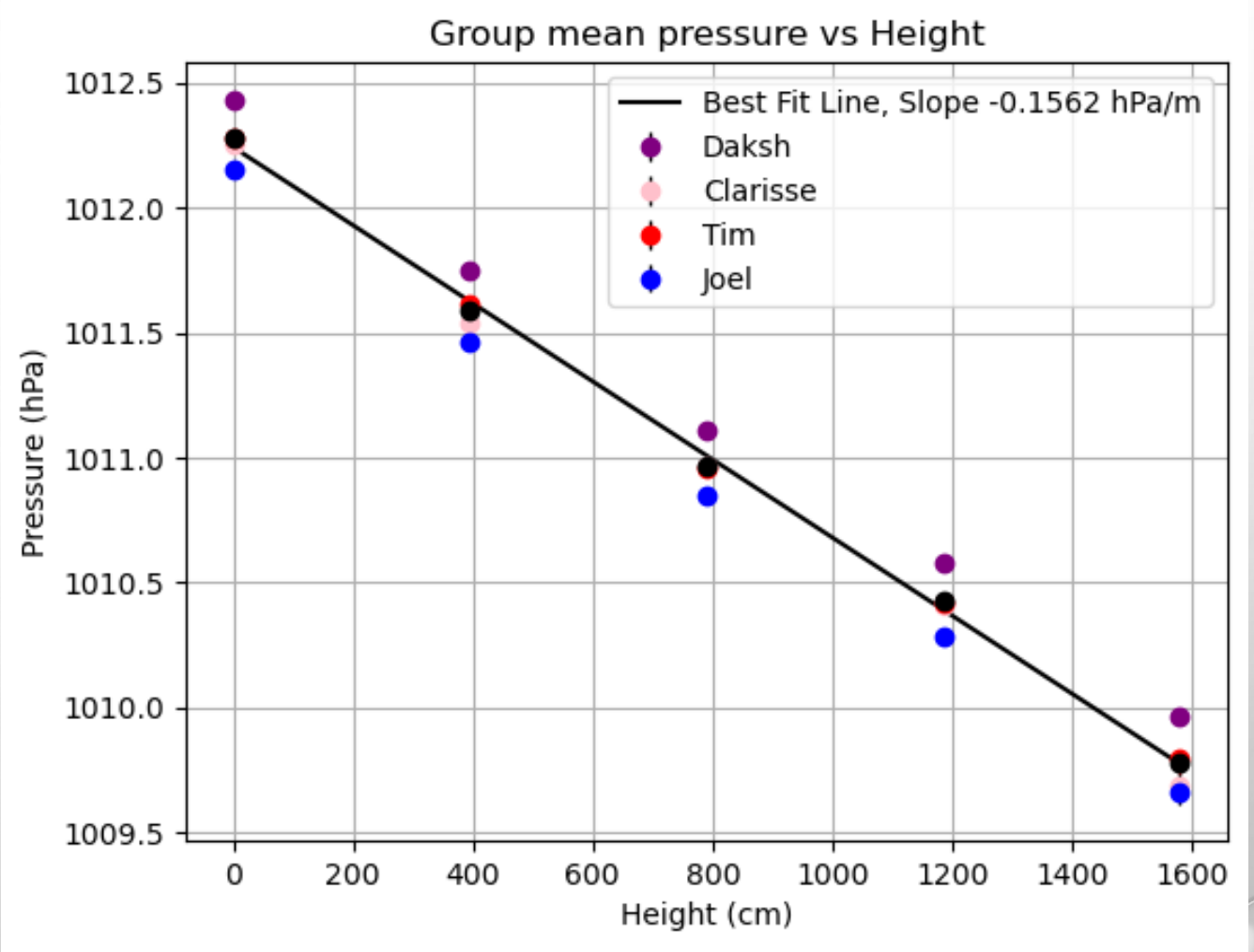
Using the $|\mu_{group} - \mu_{ind}|$ we can visualize how far off an individual was from the agreed measurement.

This graph illustrates the relative accuracy of each device across the five floors. Error bars represent the internal stability (standard deviation) of each sensor. The consistent horizontal trends demonstrate that despite small absolute offsets ($\approx 0.06\ \mathrm{hPa}$), the sensors maintain high relative precision throughout the experiment.



MODELING THE RELATIONSHIP BETWEEN PRESSURE VS HEIGHT

The data points represent the group average of four smartphone barometers at five floor levels. Error bars denote ±1 standard deviation of the measured pressure at each floor. The black line represents the linear best-fit ($P = -0.1562y + P_0$), used to derive experimental air density.



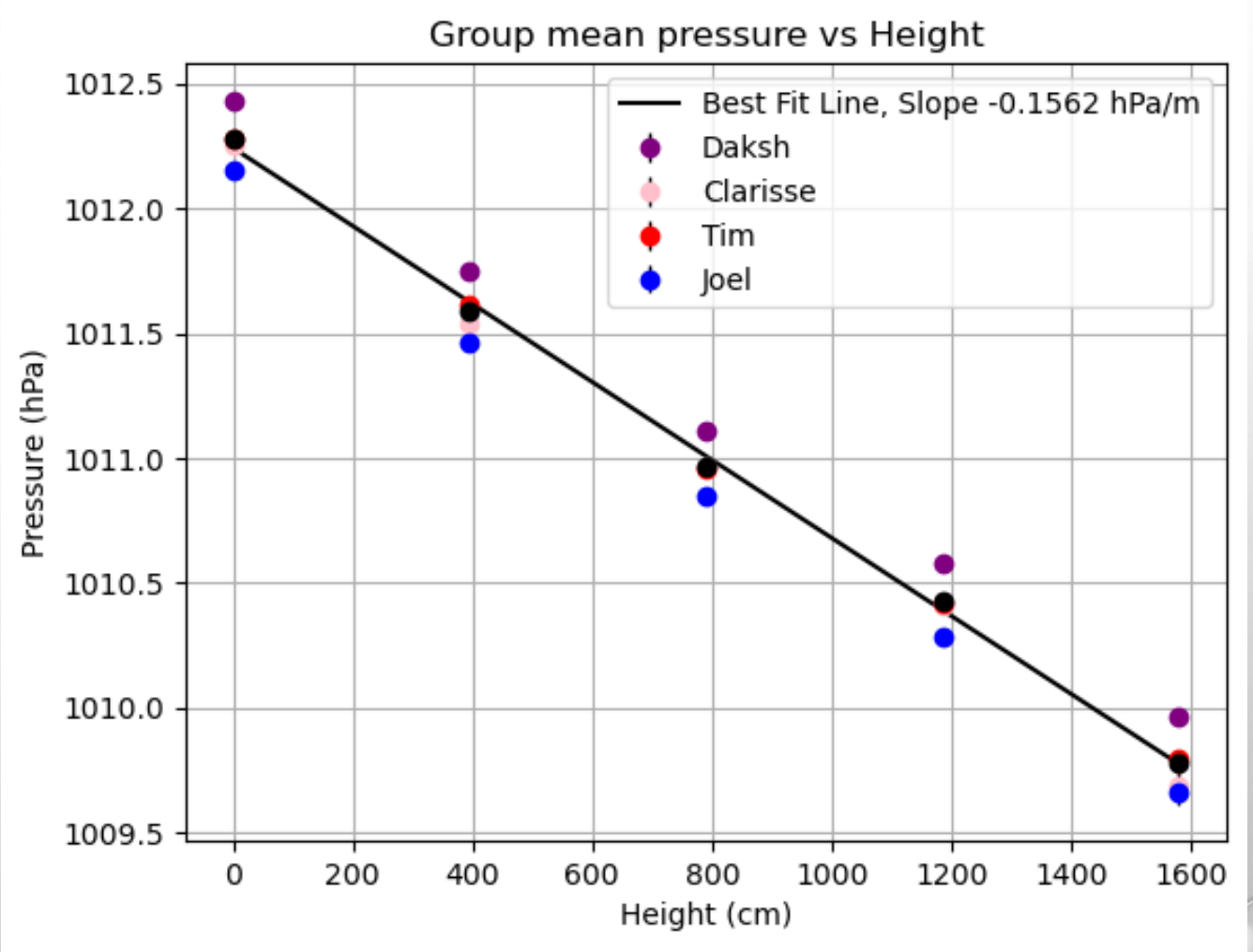
MODELING THE RELATIONSHIP BETWEEN PRESSURE VS HEIGHT

The slope finds an experimental air density of $1.5927\,kg/m^3$ with a percent error of 32.37% to the theoretical density of $1.2032\,kg/m^3$.

Using $P = P_0 - \rho g y$, the derived air density from hPa to kg/m^3 is

$$\rho_{\text{experimental}} = \frac{-(slope \times 100)}{g}$$

The theoretical air density was found using ideal gas law at $T = 20°C$, $M = 0.02897\,kg/mol$, $R = 8.314\,J/(mol \cdot K)$, $P = 101227.93\,Pa$



HEIGHT DISCREPANCY

The height was estimated to be 395cm or about 4m between each floor. A 32% error in the slope suggest that the barometers think we are not changing each floor by 4m.

If we use $\Delta y = \frac{\Delta P}{g\rho_{theo}}$

We get 5.3m

- SOURCES OF ERROR
  - Active ventilation may have caused pressure gradients independent of altitude

CONCLUSION

the results are shocking

- The barometric data indicates an actual average floor height of 5.30 meters. Although the floors were initially estimated at 4m, the measured pressure drop per floor $(0.6257\ \text{hpa})$ indicates a significantly greater vertical distance. While factors such as building ventilation (creating non-static gradients) could influence the results, the most robust physical explanation for the consistent pressure drop is that the architectural height of each floor is approximately 5.30 meters.

Confidence interval is for regression