IB Physics 1
Period
October 3, 2018
Lab

Aluminum Density Lab: An Exercise in Propagating Uncertainties and Graphical Analysis

Data Collection:

Table 1: Masses of Aluminum Objects | Raw Data					
	Mass (grams) $\pm$ 0.02g				
Object	trial 1	trial 2	trial 3	trial 4	trial 5
small cube	5.28	5.52	5.56	5.22	5.29
large cube	89.04	89.04	87.27	87.78	87.54
slab	38.00	38.92	39.15	39.18	38.95
short, small cylinder	2.75	2.75	2.74	2.74	2.74
skinny, small cylinder	2.69	2.71	2.69	2.70	2.70
large, wide cylinder	199.24	199.70	199.17	199.2	199.16
long, med., small dia. cyl.	29.03	29.09	28.9	29.11	28.98
long, med., large dia. cyl.	69.77	70.13	64.05	70.20	63.81

Uncertainty explanation:

I used the electronic balance with an uncertainty of ± 0.02g to find the mass of all of my objects because it gave me the most precise measurement between the two options I had available to me for measuring mass, the triple beam balance and the electronic balance. I used the electronic balance for all of the objects to keep the uncertainties and units constant for later calculations and comparisons. The uncertainty was given by the manufacturers of the scale and there was little to no change in the uncertainty when measured and no need to calculate my own uncertainty.

Table 2: Dimensions of Aluminum Objects | Raw Data						
		Measurements (cm) $\pm$ 0.005cm				
Object	**Dimension**	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
	Length	1.260	1.270	1.270	1.260	1.260
	Width	1.260	1.270	1.270	1.260	1.260
small cube	Height	1.260	1.270	1.270	1.260	1.260
	Length	3.210	3.200	3.200	3.200	3.205
	Width	3.205	3.200	3.200	3.200	3.200
large cube	Height	3.200	3.200	3.200	3.200	3.200
	Length	2.550	2.660	2.650	2.560	2.550
	Width	0.630	0.635	0.640	0.630	0.645
slab	Height	8.990	8.985	8.940	8.860	8.860
	Diameter	0.960	0.950	0.960	0.955	0.955
short, small cylinder	Height	1.930	1.925	1.920	1.195	1.92
	Diameter	0.880	0.870	0.870	0.865	0.875
skinny, small cylinder	Height	5.130	5.135	5.130	5.135	5.135
	Diameter	4.445	4.460	4.460	4.440	4.440
large, wide cylinder	Height	4.735	4.720	4.745	4.735	4.740
	Diameter	1.270	1.270	1.270	1.270	1.270
long, med., small dia. cyl.	Height	8.46	8.47	8.49	8.49	8.49
	Diameter	1.915	1.900	1.905	1.915	1.950
long, med., large dia. cyl.	Height	8.645	8.750	8.390	8.655	8.310

Uncertainty explanation:

I used a Vernier Caliper with an uncertainty of ±0.005cm to measure the dimensions of all of the objects because the range for the measurements on the Vernier caliper fit the dimensions of each object while as the micrometer did not. The ruler could have been used but I used the Vernier caliper provided a more precise measurement and was used for all of the objects to keep the units and uncertainties constant. The uncertainty used was half of the smallest graduation of the scale on the caliper.

Data Analysis:

Table 3: Average Aluminum Object Mass with Uncertainties: Calculated Data		
Object	**Averages (grams)**	**Uncertainty ($\pm$ grams)**
small cube	5.4	0.2
large cube	88.1	0.9
slab	38.8	0.6
short, small cylinder	2.744	0.005
skinny, small cylinder	2.70	0.01
large, wide cylinder	199.3	0.3
long, med., small dia. cyl.	29.0	0.1
long, med., large dia. cyl.	68	3

Sample calculations:

$$average\ mass = \frac{\sum mass\ values}{total\ number\ of\ values}$$

Example calculation for average mass of small cube

$$\frac{15.28 + 15.52 + 5.56 + 5.22 + 5.29}{5} = 5.374 = 5.4g$$

$$average\ mass\ uncerainty = \frac{1}{2}(Value_{max} - Value_{min})$$

Example calculation for uncertainty of mass of small cube

$$\frac{1}{2} * (5.56 - 5.22) = 0.17 \approx 0.2g$$

Table 4: Average Aluminum Object Dimensions with Uncertainties: Calculated Data			
Object	**Dimension**	**Averages (cm)**	**Uncertainties ($\pm$ cm)**
small cube	Length	1.264	0.005
	Width	1.264	0.005
	Height	1.264	0.005
large cube	Length	3.203	0.005
	Width	3.201	0.002
	Height	3.20	0.01
slab	Length	2.59	0.06
	Width	0.64	0.01
	Height	8.93	0.07
short, small cylinder	Diameter	0.956	0.005
	Height	1.8	0.4
skinny, small cylinder	Diameter	0.872	0.008
	Height	5.133	0.002
large, wide cylinder	Diameter	4.45	0.01
	Height	4.74	0.01
long, med., small dia. cyl.	Diameter	1.270	0.005
	Height	8.48	0.01
long, med., large dia. cyl.	Diameter	1.92	0.03
	Height	8.6	0.2

Sample calculations:

Length

$$average\ length = \frac{\sum length\ values}{total\ number\ of\ values}$$

Sample calculation for average length of small block

$$\frac{1.260 + 1.270 + 1.270 + 1.260 + 1.260}{5} = 1.264cm$$

$$average\ length\ uncerainty = \frac{1}{2}(Value_{max} - Value_{min})$$

Sample calculation for uncertainty of length of small block

$$\frac{1}{2} * (1.270 - 1.260) = 0.005cm$$

Width

$$average\ width = \frac{\sum width\ values}{total\ number\ of\ values}$$

Sample calculations for average width of small block

$$\frac{1.260 + 1.270 + 1.270 + 1.260 + 1.260}{5} = 1.264cm$$

$$averagewidth\ uncerainty = \frac{1}{2}(Value_{max} - Value_{min})$$

Sample calculation for uncertainty of width of small block

$$\frac{1}{2} * (1.270 - 1.260) = 0.005cm$$

Height

$$average\ height = \frac{\sum height\ values}{total\ number\ of\ values}$$

Sample calculations for average height of small block

$$\frac{1.260 + 1.270 + 1.270 + 1.260 + 1.260}{5} = 1.264cm$$

$$average\ height\ uncerainty = \frac{1}{2}(Value_{max} - Value_{min})$$

Sample calculation for uncertainty of height of small block

$$\frac{1}{2} * (1.270 - 1.260) = 0.005cm$$

Diameter

$$average\ diameter = \frac{\sum diameter\ values}{total\ number\ of\ values}$$

Sample calculation for average diameter of short, small cylinder

$$\frac{0.960 + 0.950 + 0.960 + 0.955 + 0.955}{5} = 0.956cm$$

$$average\ length\ uncerainty = \frac{1}{2}(Value_{max} - Value_{min})$$

Sample calculation for uncertainty of length of small block

$$\frac{1}{2} * (0.960 - 0.950) = 0.005cm$$

Table 5: Volumes of Aluminum Objects with Uncertainties: Calculated Data		
	Volume with Uncertainty	
Object	Volume (cm^3)	Uncertainty ($\pm$ cm^3)
small cube	2.02	0.02
large cube	32.8	0.1
slab	14.7	0.6
short, small cylinder	1.3	0.3
skinny, small cylinder	3.07	0.05
large, wide cylinder	73.6	0.5
long, med., small dia. cyl.	10.7	0.1
long, med., large dia. cyl.	25	1

Sample calculations:

Rectangle Objects

$$Volume = (average\ length) * (average\ width) * (average\ height)$$

Sample calculation for volume of small cube

$$(1.264) * (1.264) * (1.264) = 2.019 \approx 2.02cm^3$$

$$volume\ uncertainty = \left(\left(\frac{\Delta length}{length}\right) + \left(\frac{\Delta width}{width}\right) + \left(\frac{\Delta height}{height}\right)\right) * (volume)$$

Sample calculation for volume uncertainty of small cube

$$\left(\left(\frac{0.005}{1.264}\right) + \left(\frac{0.005}{1.264}\right) + \left(\frac{0.005}{1.264}\right)\right) * (2.02) = 0.02cm^3$$

Cylinder Objects

$$volume = \pi * \left(\frac{diameter}{2}\right)^2 * height$$

Sample calculation for volume of short, small cylinder

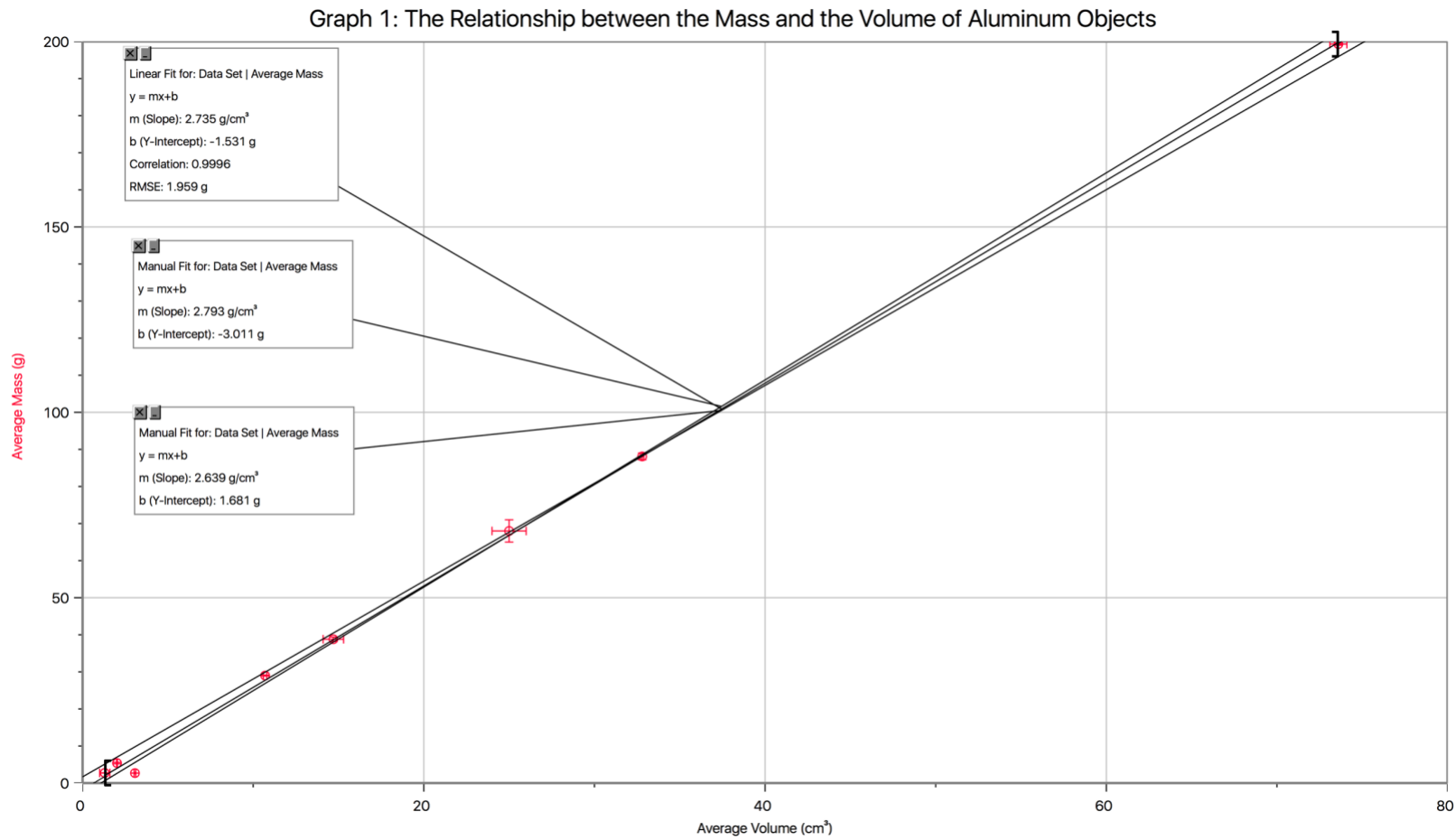
$$\pi * \left(\frac{0.956}{2}\right)^2 * 1.8 = 1.29 \approx 1.3cm^3$$

$$volume\ uncertainty = \left(2 * \left(\frac{\Delta diameter}{diameter}\right) + \left(\frac{\Delta height}{height}\right)\right) * (volume)$$

Sample calculation for volume uncertainty of short, small cylinder

$$\left(2 * \left(\frac{0.005}{0.956}\right) + \left(\frac{0.4}{1.8}\right)\right) * (1.3) = 0.3cm^3$$

Graph:



Slopes for Density

MAX: 2.79 g/cm^3

Average: 2.74 g/cm^3

MIN: 2.64 g/cm^3

Slope uncertainty calculation

$$\Delta slope = \frac{(max\ slope) - (\min slope)}{2}$$

$$uncertainty = \frac{2.79 - 2.64}{2}$$

$$= 0.08 g/cm^3$$

Conclusion:

Final Density for Aluminum: $2.74\ g/cm^3 \pm 0.08 g/cm^3$

The final conclusion for the density of aluminum from the data and the slope of the graph is $2.74\ g/cm^3 \pm 0.08 g/cm^3$.

The purpose of the lab was to find the dimensions and masses of various aluminum objects and calculate the volumes of such objects to then use to plot on a graph and find the density of aluminum. The slope of the graph on the Volume vs. Mass axis represents the density of aluminum, given by the mass (x change) over the volume (y change), the equation for finding density. By using LoggerPro, the slope was given as $2.74\ g/cm^3 \pm 0.08 g/cm^3$ being the average density of all the aluminum objects.