Physics Laboratory Report

Title: **Equilibrium Experiment**

Lab number and Title: **Lab 7: Archimedes' Principle and Density**

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Date of Experiment: **12/07/2023**

Date of Report Submission: **12/07/2023**

Course and Section Number: **PHYS 111A-011**

Group ID: **Group 3**

Instructor's Name: **Prof. Tomie Nguyen**

Partner's Names: **Logan Chappell, Jose Tabuena, Connor Nguyen**

1. **Results**
    a. ***Data***

Data Tables

Table I

Water Ethanol

Cylinder ID	Height [m]	Diameter [m]	V_o [m³]	W [N] in air	W' [N] in liquid 1	W' [N] in liquid 2
A	0.03824	0.02545	1.95×10^{-5}	0.5408	0.3453	0.3742
B	0.02524	0.02546	1.29×10^{-5}	0.32155	0.2245	0.2327
C	0.01272	0.02552	6.47×10^{-6}	0.1717	0.1115	0.1138

Table II

Density of water ρ_L: 998.9286 kg/m³

Air Water

Block ID	Vo [m³]	W [N]	W' [N]	Density of Block ρ_o [kg/m³] By Archimedes' Principle	Density of Block ρ_o [kg/m³] By Density Definition	Substance
U	3.19×10^{-5}	3.4176	3.1058	10,949.129	10,872.16	Lead
W	3.19×10^{-5}	2.4746	2.1574	7,753.029	7,885.85	Iron
X	3.19×10^{-5}	2.6559	2.3431	8,481.632	8,470.22	Brass
Y	3.19×10^{-5}	0.8613	0.5412	2,687.837	2,740.44	Aluminum

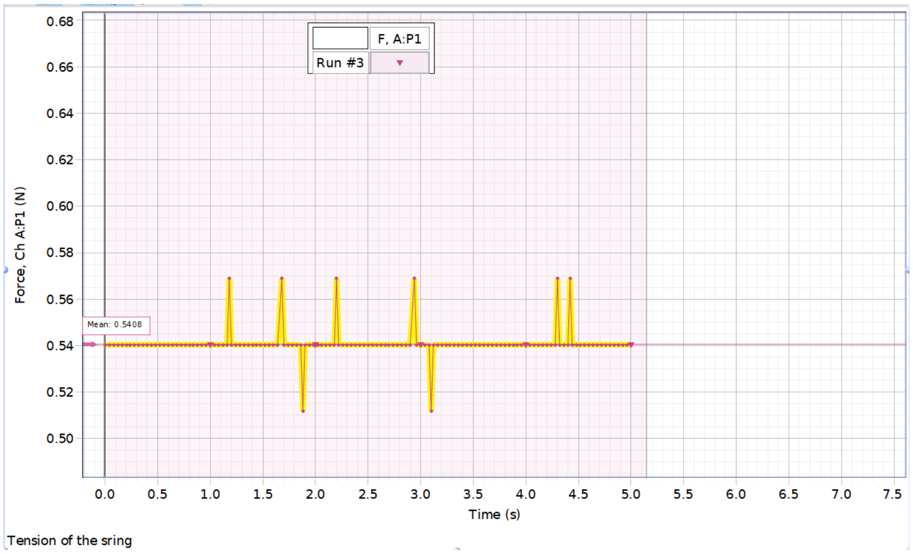
b. Experiment One

i. Experimental Data

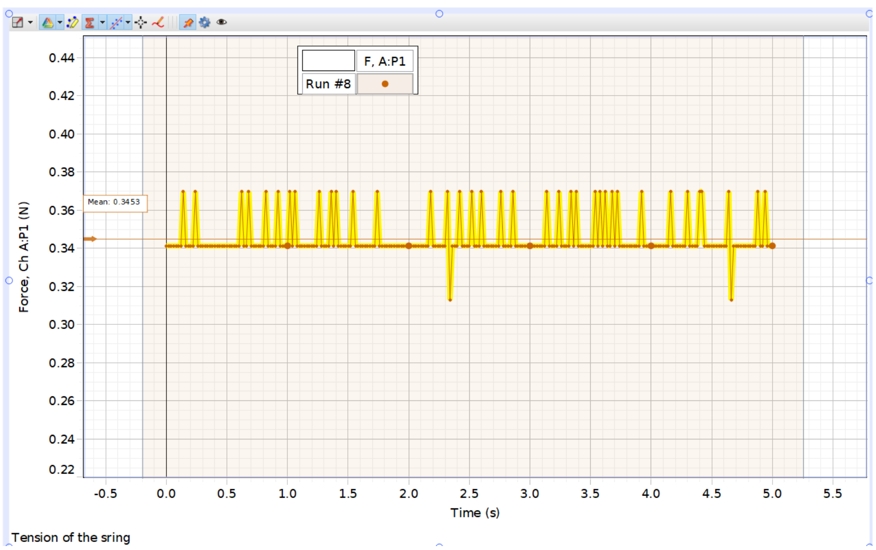
Cylinder A

Mass = 0.05485kg

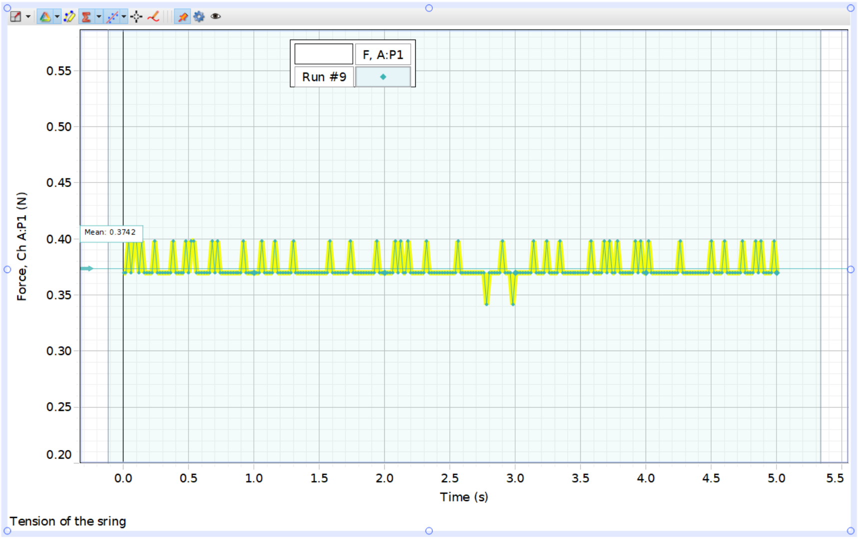
Weight in air



Weight in Water



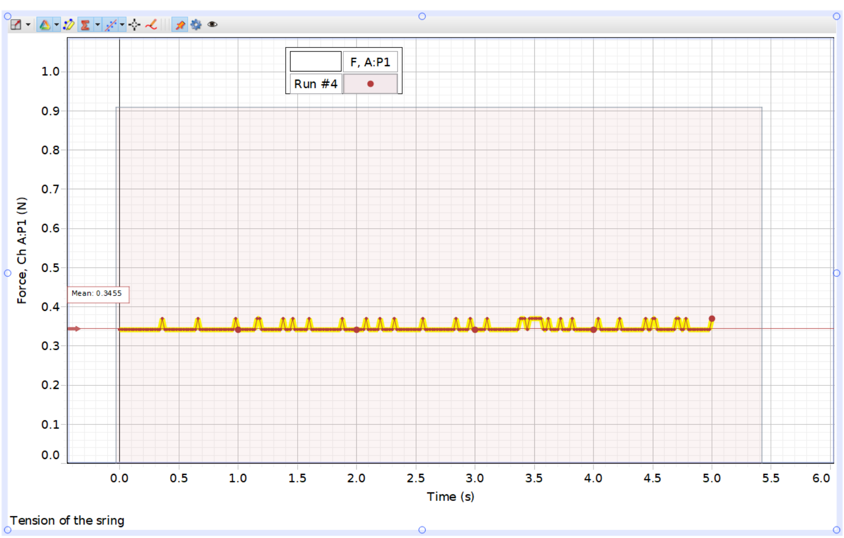
Weight in Ethanol



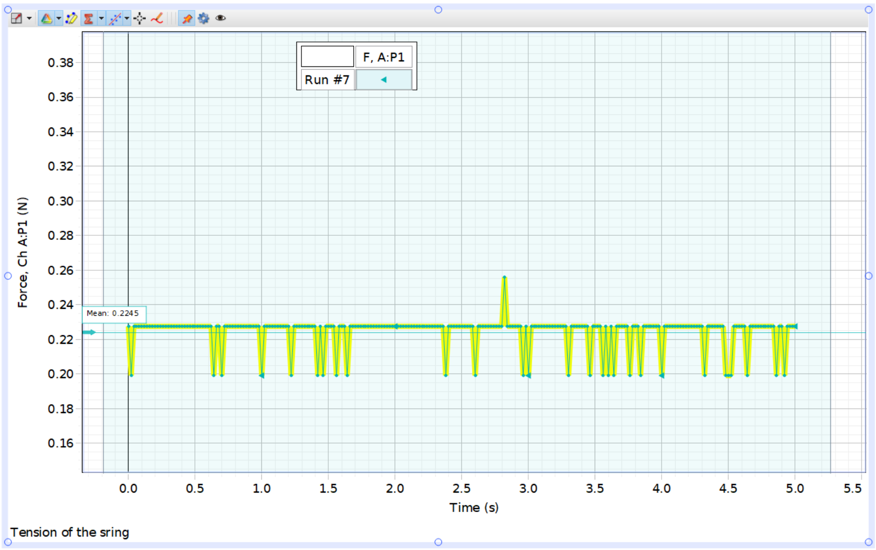
Cylinder B

Mass = 0.03535kg

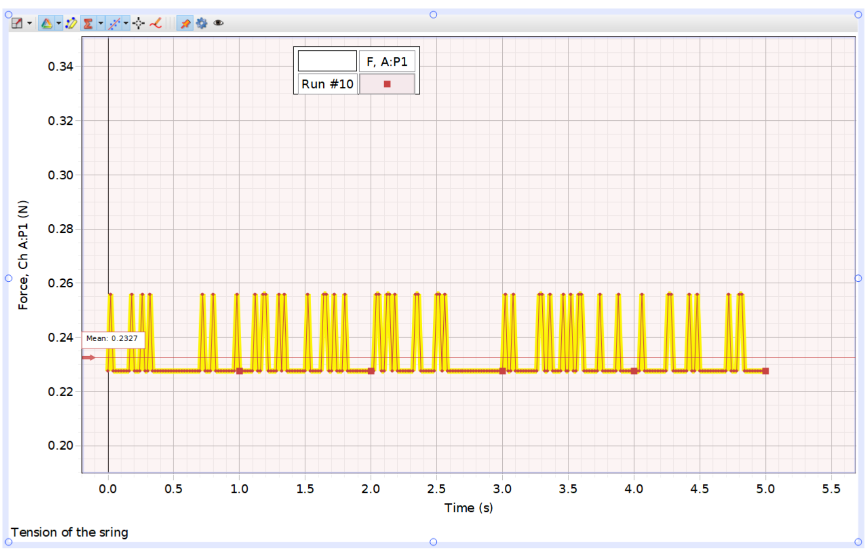
Weight in air



Weight in Water



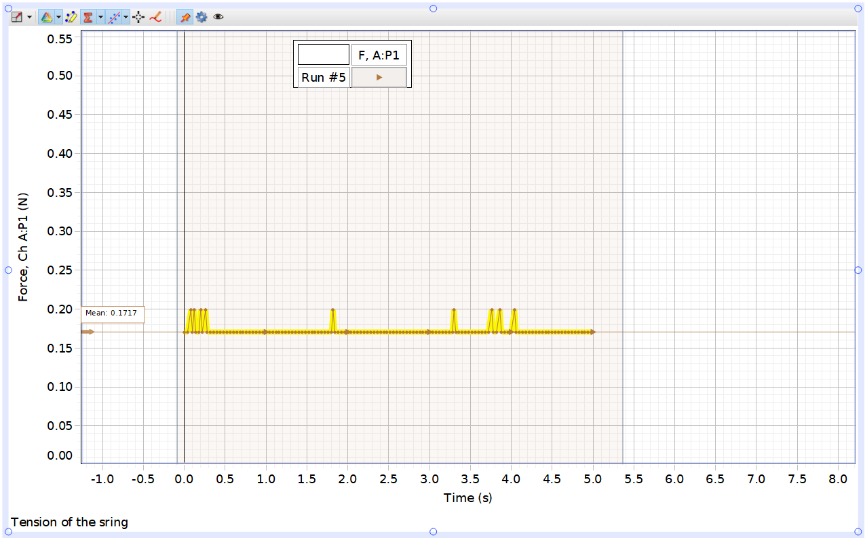
Weight in Ethanol



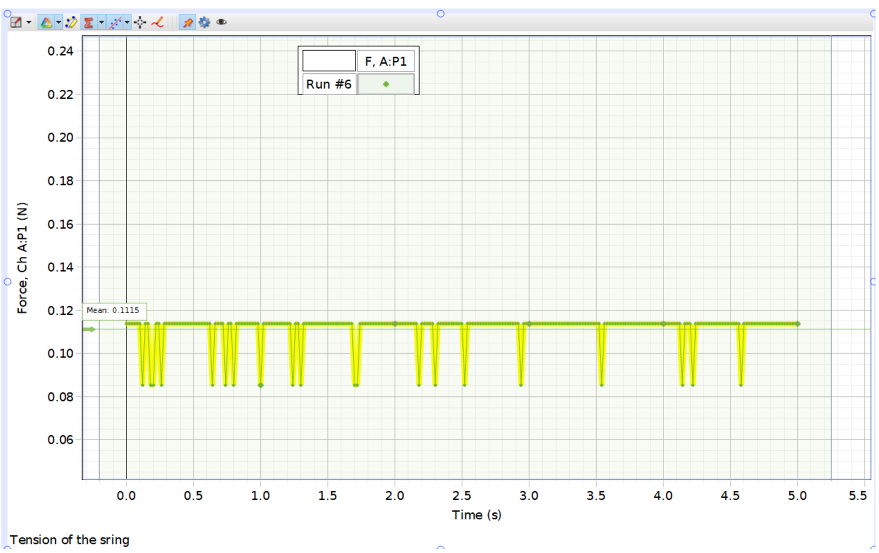
Cylinder C

Mass = 0.01765kg

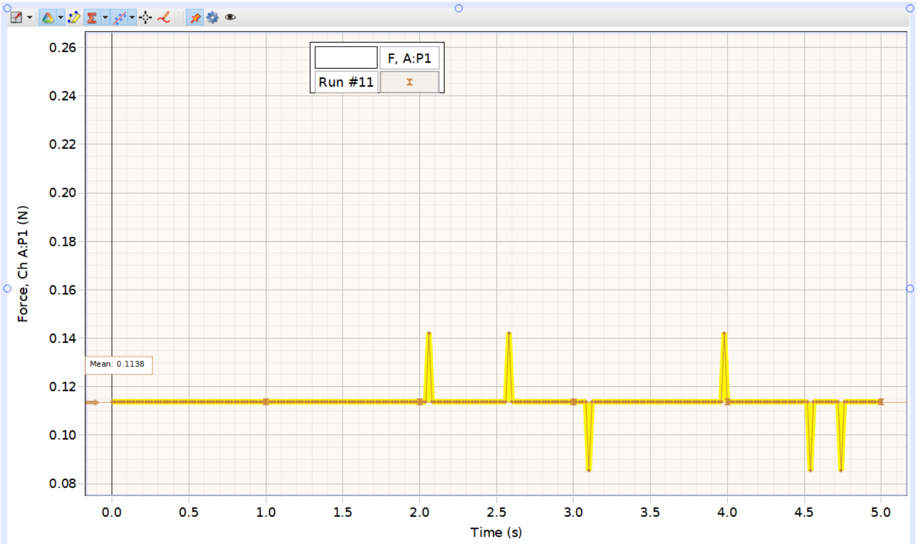
Weight in air:



Weight in Water

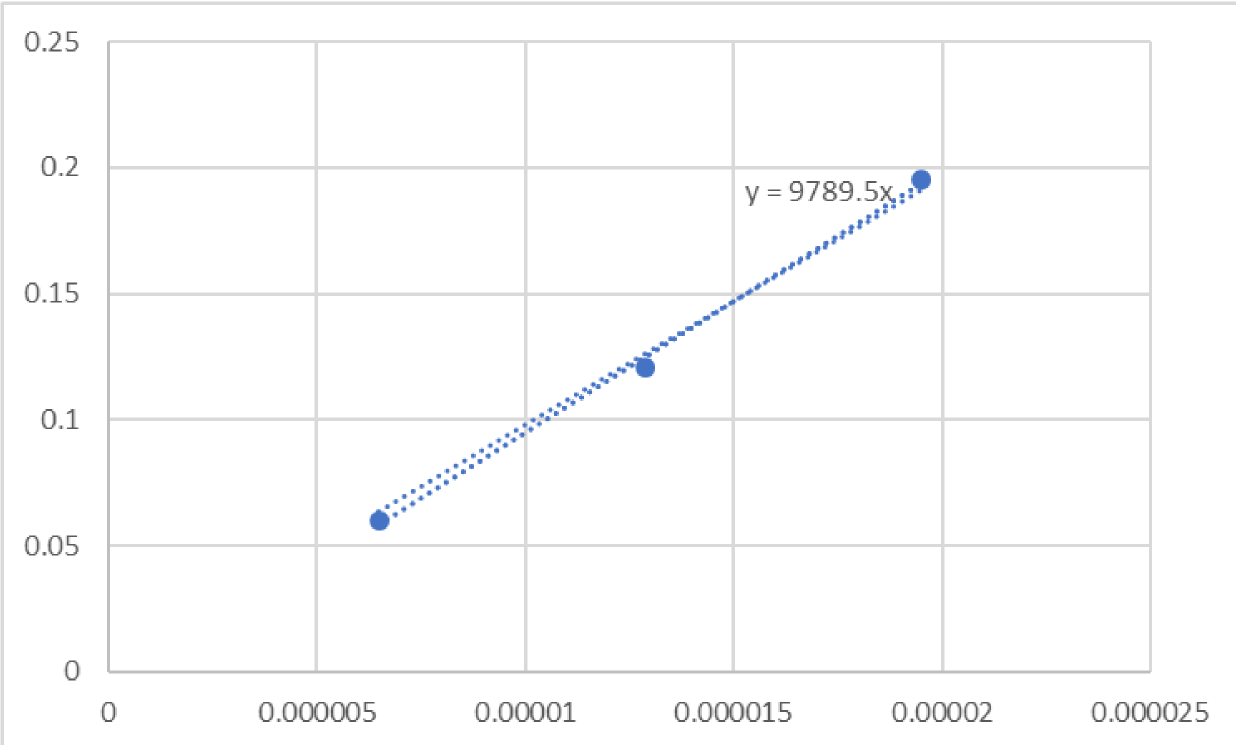


Weight in Ethanol



Tension of the sring

c. Experiment Two

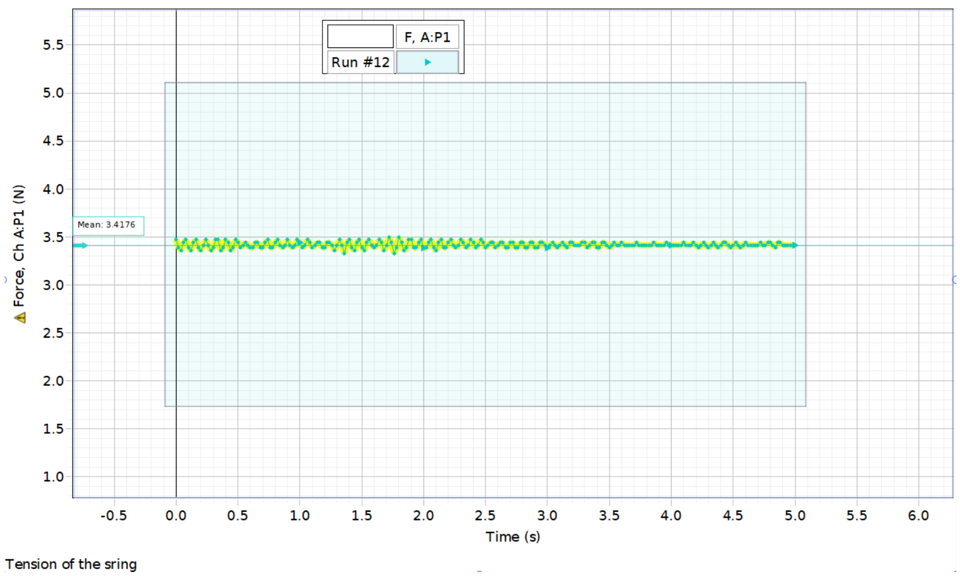


Density of Water: 998.9286 kg/m^3.

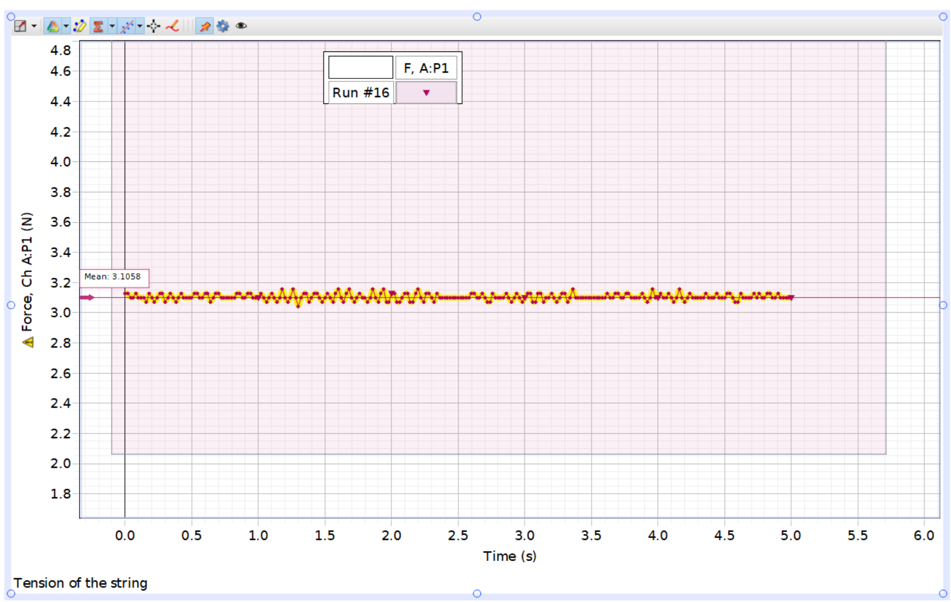
Block U

Mass = 0.34756kg

Weight in Air



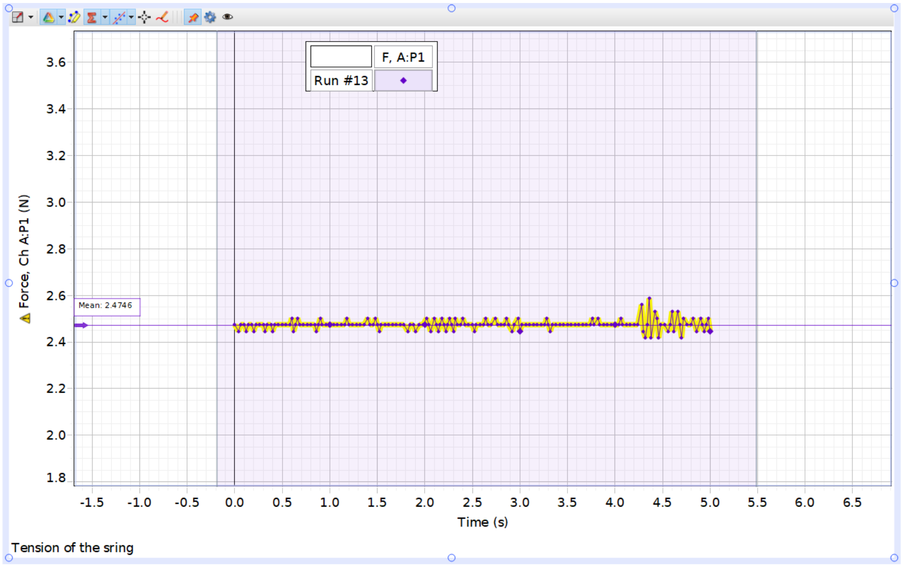
Weight in Water



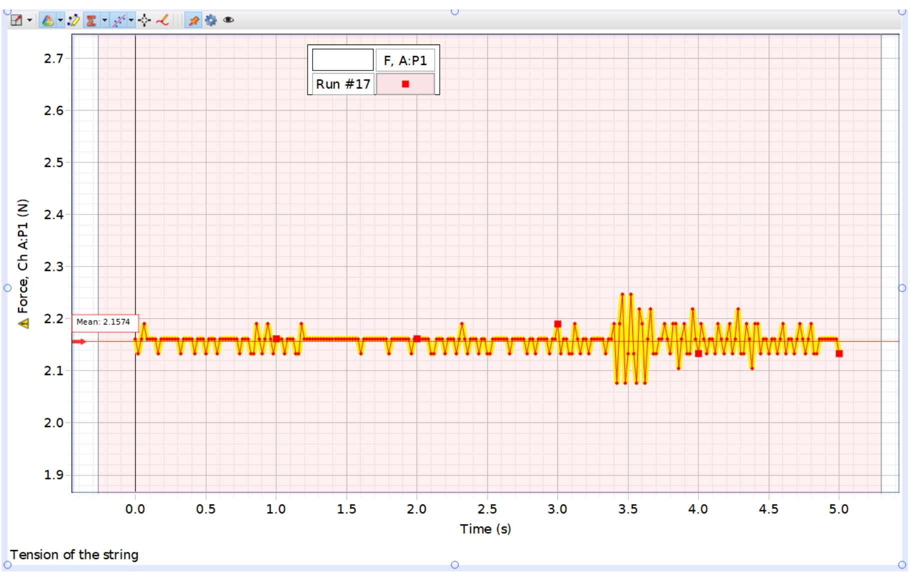
Block W

Mass = 0.25156kg

Weight in Air



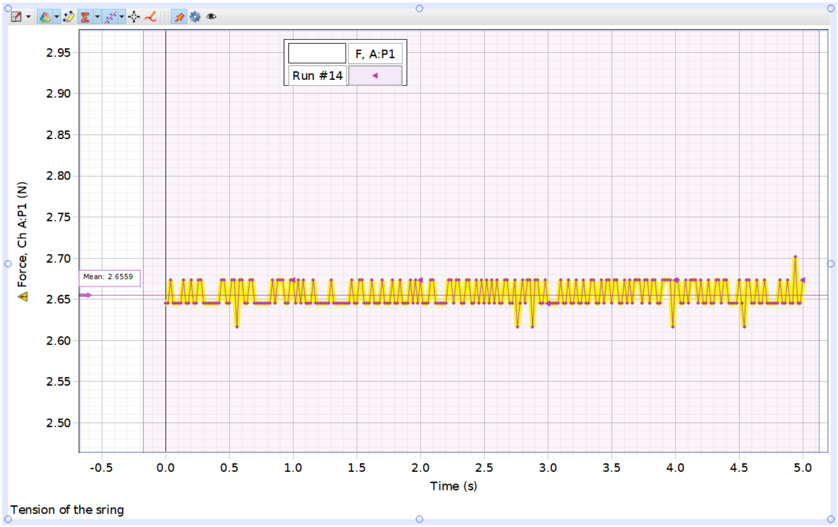
Weight in Water



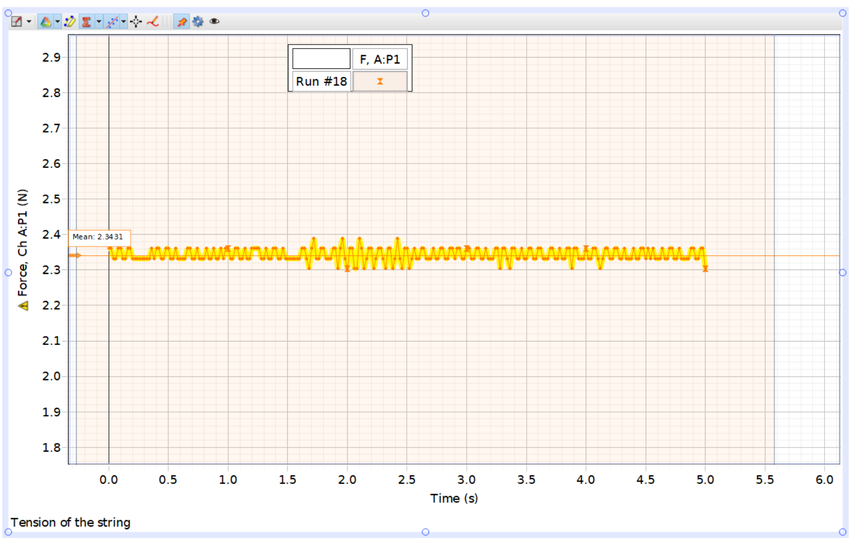
Block X

Mass = 0.27020kg

Weight in Air



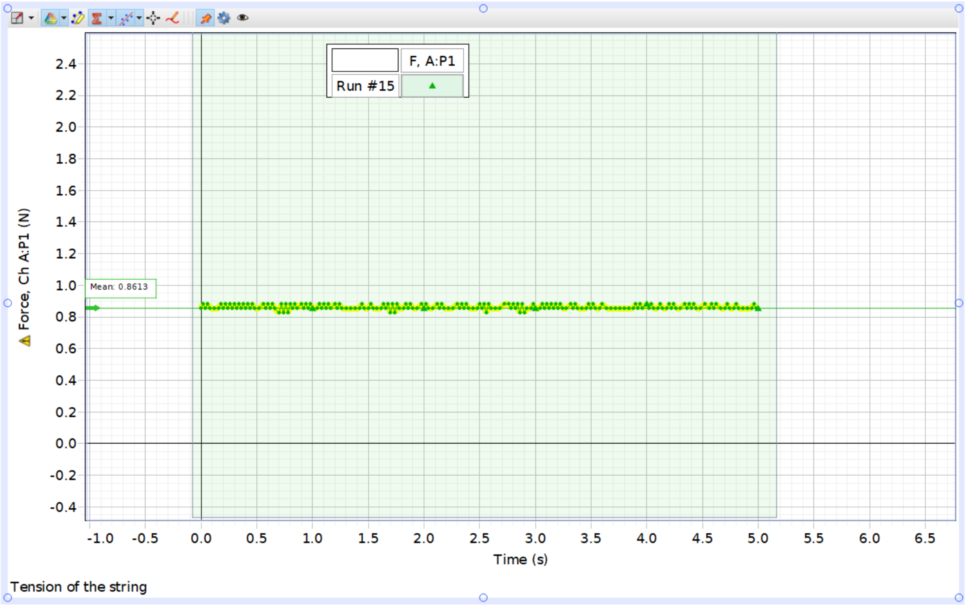
Weight in Water



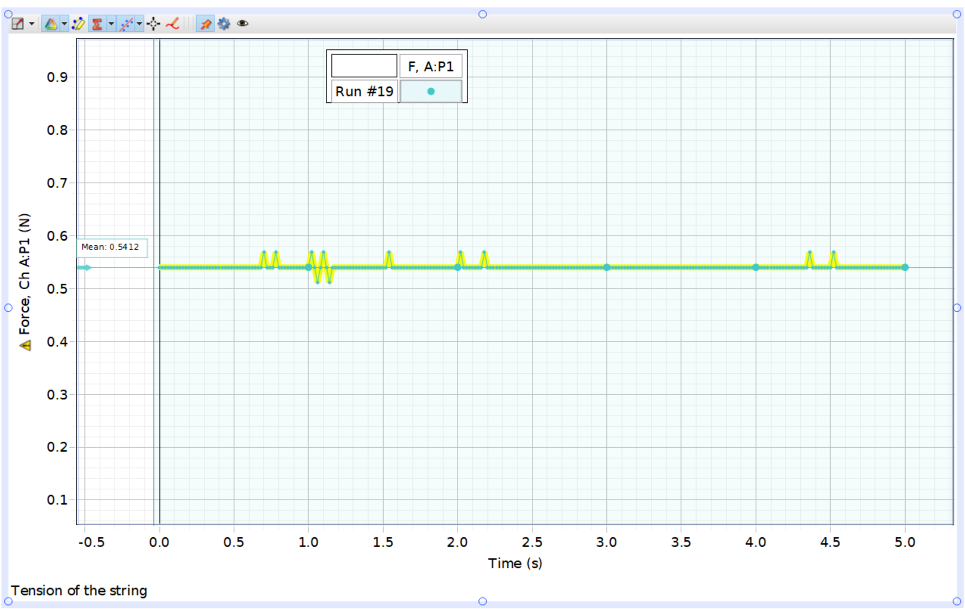
Block Y

Mass = 0.08742

Weight in Air



Weight in Water



d. Calculations

Calculations:

Table 1:

$$V_0 (\text{cylinder}) = \pi r^2 h$$

$$V_{0\,\text{cylinder}A} = \pi \left(\frac{0.02545}{2}\right)^2 (0.03824) = 1.95 \times 10$$

$$V_{0\,\text{cylinder}B} = \pi \left(\frac{0.02546}{2}\right)^2 (0.02524) = 1.29 \times 10$$

$$V_{0\,\text{cylinder}C} = \pi \left(\frac{0.02553}{2}\right)^2 (0.01272) = 6.49 \times 10$$

Actual Cylinder Weights: $W = mg$

Cylinder A $= 0.05485 \times 9.8 = 0.53753\,N$

Cylinder B $= 0.3535 \times 9.8 = 0.34643\,N$

Cylinder C $= 0.01765 \times 9.8 = 0.17297\,N$

Table 11:

V_0 (cube) $= x^3$

V_0 cube V $= 0.0317^3 = 3.19 \times 10^{-5}$

V_0 cube W $= 0.0317^3 = 3.19 \times 10^{-5}$

V_0 cube X $= 0.0317^3 = 3.19 \times 10^{-5}$

V_0 cube Y $= 0.0317^3 = 3.19 \times 10^{-5}$

Densities of Blocks:

Archimedes Principle: $\rho_0 = \frac{\rho_L W}{W - W'}$

Cube V $= \frac{998.9286(3.4176)}{3.4176 - 3.1058} = 10949.129 \frac{kg}{m^3}$

Cube W $= \frac{998.9286(2.4746)}{2.4746 - 2.1574} = 7793.029 \frac{kg}{m^3}$

Cube X $= \frac{998.9286(2.6559)}{2.6559 - 2.3431} = 8481.632 \frac{kg}{m^3}$

Cube Y $= \frac{998.9286(0.8613)}{0.8513 - 0.5412} = 2687.839 \frac{kg}{m^3}$

Density Definition: $\frac{m}{V}$

$$\text{Cube V} = \frac{0.3474}{3.19\times10^{-5}} = 10892.278\ \frac{kg}{m^3}$$

$$\text{Cube W} = \frac{0.2515}{3.19\times10^{-5}} = 7885.89\ \frac{kg}{m^3}$$

$$\text{Cube X} = \frac{0.2702}{3.19\times10^{-5}} = 8472.72\ \frac{kg}{m^3}$$

$$\text{Cube Y} = \frac{0.08742}{3.19\times10^{-5}} = 2740.4\ \frac{kg}{m^3}$$

2. **Analysis and Discussion**
    1. **Questions**
        a. Question one asks how our experimental values compare to the accepted values in part one, and where the errors could have arisen from. The difference between the values is around 0.6% for each of them, which is extremely low. The small differences between the theoretical and experimental values could have arisen from machine error and rounding, which play non-significant roles in the experimentation. The experiment's solution shows that Archimedes' Principle is reliable in order to theoretically solve for the buoyant force's components, which in this case was density.
        b. Question two looks at part two of the experiment, and asks how close the density values are. It also asks us to determine if Archimedes' Principle is accurate. Comparing the values we

found using Archimedes' principle to the other values we found in the graph, we found a very small difference between the two. This confirms that Archimedes’ Principle is a reliable method of calculating density.

c. Question three has a hypothetical about an ice cube floats in a glass of water, and asks if the glass would overflow as the ice melts. Since the ice is floating, it isn’t contributing to the volume of the liquid, but as it begins melting the water it does join the water underneath. This would mean that the water inside the flask would increase and ultimately overflow.
d. Question four asks why we would float more easily in the ocean than in freshwater. This is because the density of ocean water, which has salt and other heavier minerals, is higher than that of freshwater, therefore the buoyant force is much higher. This means that when you are in the ocean, you are dealing with a much higher upward push, and you need to have a heavier weight in order to sink.
e. The last question provides a hypothetical of two helium balloons with the only difference being one being a rigid structure while the other is free to expand. Using Archimedes’ Principle, we can determine that the balloon with a rigid structure, which would have a constant volume, would be able to displace more and therefore have a higher buoyant force applied to it, whereas with the deforming structure, the volume can change

2.

3. Conclusions

To conclude this lab report, we have learned buoyancy and the different factors that are applied to calculate it. In the two experiments, we had to apply our understanding of buoyancy to calculate the density of water, and how the tension force changes as objects are submerged into water. The experiment had the group intrigued in how other fluids with more drastic differences (such as honey) would be affected, which would also make for a more exciting set of experiments. Furthermore, another thing to look into is playing with objects that are not rigid, but instead apply nonrigid structures. One problem in the experiment was that the liquid did get messy, but in the end it was fun. Overall, I found this lab very insightful and would love to learn more.