Title: Weighing and Pipetting Experiment

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Abstract: There are two experiments that were conducted within this report. The first was the weighing of water section and the second was the weighing of different types of coins, specifically pennies, nickels, dimes, and quarters. In the water weighing part of the experiment, an empty 100-mL Nalgene polyethylene bottle with cap was weighed. After weighing increments of 5-mL of water was pipetted into the bottle and weighed five times during each addition of water. This allowed for the determination of water mass and can be used to determine the density of water to be 1.0024g/mL at 23℃. For the coin weighing part of the experiment, each coin was weighed once with a tared weighing boat and massed three more times with an untared weighing boat for the rest of the four coins provided. This was the first determination of the average mass of these coins. The second determination was using only one coin in a tared boat and massed three more times with an untared weighing boat. The massing of coins allowed for coin analysis, specifically chemical compositions of the coins. The mean mass for the penny was 2.7507g, the nickel was 5.0203g, the dime was 2.2736g, and the quarter was 5.6960g.

I. Introduction:

The goal of this experiment was to collect and analyze data that was recorded by measuring water pipetted in 5-mL increments five times to reach a volume of 25-mL and to weigh US coins, the penny, nickel, dime, and quarter, from different times to determine if the coins have changed in their chemical compositions. The first equation that was used in the Results section of the report was the mean equation. The mean equation [1] is,

$$\bar{x} = \frac{\sum_{i=1}^{N} x_i}{N} = \frac{(x_1 + x_2 + x_3 + \cdots + x_N)}{N}$$

where $\bar{x}$ is the mean, N is the number of observations, and $\sum_{i=i}^{N} x_i$ is the sum of all individual values x_i. The second equation that was used was the sample standard deviation equation [1] where

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(\overline{X} - X_i)^2}{n-1}};$$

σ is the standard deviation, $\bar{x}$ is the mean, and n is the number of observations. The third equation used was the percent relative standard deviation [1] where

$$\%\,\mathrm{RSD} = \frac{s}{\bar{x}} \times 100$$

s is the standard deviation, and $\bar{x}$ is the mean. The last equation that was used was the percent error equation where,

$$\left|\frac{E - T}{T}\right| * 100 = \%\, Error$$

E is the experimental value, T is the theoretical value.

II. Experimental:

Equipment:

Accumax Pro Pipet (1-5 mL)

Electronic Balance for water weighing: OHaus brand, Serial Number: 2861, GA110, Labeled with Beck 2 Machine

Electronic Balance for coin weighing: Mettler Toledo brand, AG204, Bal-15 label

Coin Bag Set 3

Thermometer

Equipment continuation:

100 mL Beaker

100 mL Nalgene polyethylene bottle with cap

Weighing Boat

Procedure:

<u>Experiment 1:</u>

To begin, an empty polyethylene 100 mL bottle and cap was measured to be compared to. This section of the experiment required the massing of water in 5 mL increments, 5 times each increment. This massing process continues until the 5 measurements for the bottle containing 25 mL is reached. After finishing the incremental measurements, the temperature of the water was measured.

<u>Experiment 2:</u>

This section of the experiment required massing of each type of coin first with the weighing boat tared. This mass would be the standard against the other measurements that would be done with each coin. After the first coin was massed in the tared weighing boat, the next measurements would be done with the boat untared and this process would be repeated until there were no coins left to be massed.

III. Results:

Table I. Summary of Pipetting Water

Measurement #	Mass of bottle + water (g)	Mass of Water (g)	Water Volume (mL)
1	24.9360	5.0682	5.00
2	24.9361	5.0683	5.00
3	24.9363	5.0685	5.00
4	24.9361	5.0683	5.00
5	24.9362	5.0684	5.00
6	29.9256	10.0578	10.00
7	29.9256	10.0578	10.00
8	29.9259	10.0581	10.00
9	29.9257	10.0579	10.00
10	29.9258	10.0580	10.00
11	34.9376	15.0698	15.00
12	34.9378	15.0700	15.00

Table I. continuation

Measurement #	Mass of bottle + water (g)	Mass of Water (g)	Water Volume (mL)
13	34.9378	15.0700	15.00
14	34.9377	15.0699	15.00
15	34.9378	15.0700	15.00
16	39.9605	20.0927	20.00
17	39.9607	20.0929	20.00
18	39.9606	20.0928	20.00
19	39.9605	20.0927	20.00
20	39.9604	20.0926	20.00
21	44.9790	25.1112	25.00
22	44.9789	25.1111	25.00
23	44.9791	25.1113	25.00
24	44.9788	25.1110	25.00
25	44.9792	25.1114	25.00

Table II. Summary of Descriptive Statistics of Pipetting Water

Water Volume (mL)	Mean Mass of Water (g)	Standard Deviation (g)	%RSD
5.00	5.0683	0.0001	0.00
10.00	10.0579	0.0001	0.00
15.00	15.0699	0.0001	0.00
20.00	20.0927	0.0001	0.00
25.00	25.1112	0.0002	0.00

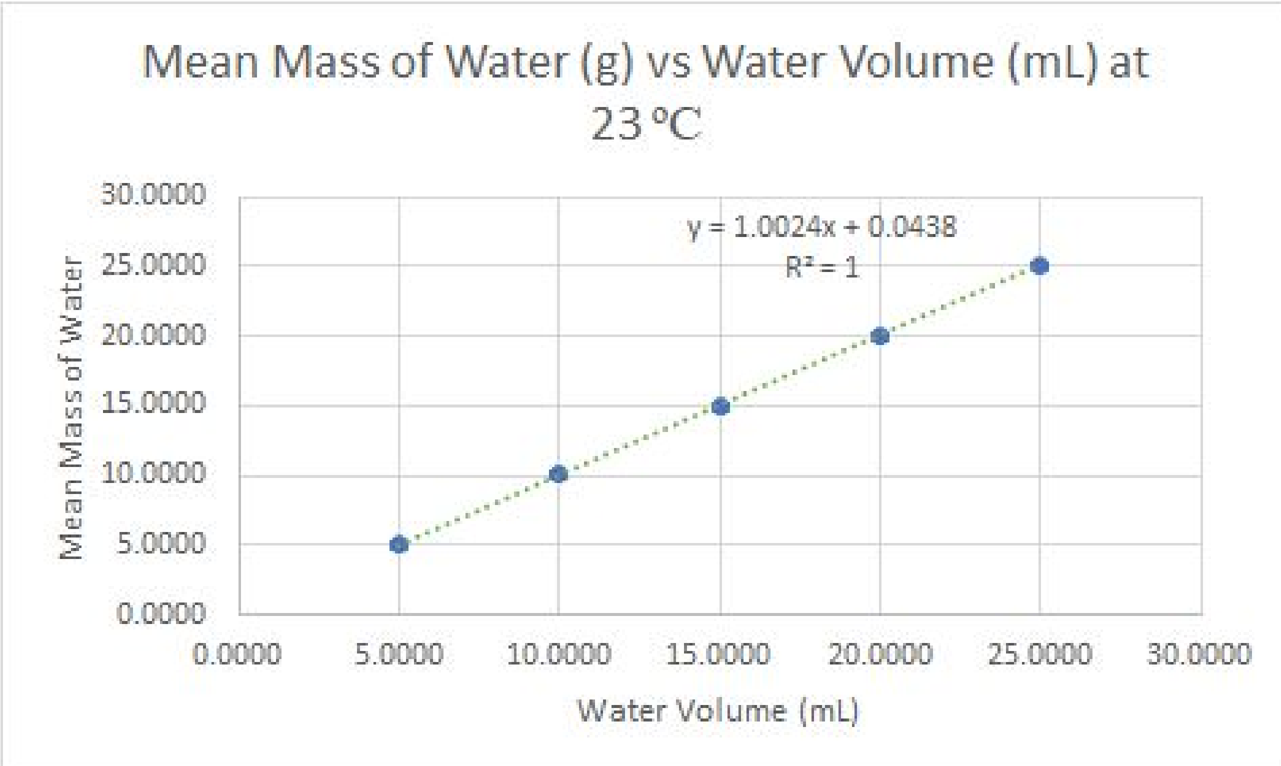

Figure 1. Graph of mass (g) water vs. volume (mL) at 23℃.

Table III. Identification and masses of different US coins

Coin Type	Mint Year ID with mint mark if any.	One Coin (g)	Mass 1 (g)	Mass 2 (g)	Mass 3 (g)
Penny	2010	2.5121	2.5129	2.5121	2.5131
Penny	1994	2.4955	2.4951	2.4953	2.5055
Penny	1982	3.0995	3.0994	3.0991	3.0999
Penny	1970	3.1233	3.1234	3.1234	3.1232
Penny	1987	2.5195	2.5198	2.5187	2.5189
Nickel	2015 D	4.9810	4.9816	4.9806	4.9808
Nickel	1972	4.9974	4.9972	4.9980	4.9978
Nickel	2015 F	4.9923	4.9926	4.9923	4.9916
Nickel	2001	4.9858	4.9850	4.9863	4.9858
Nickel	1969	5.1448	5.1442	5.1454	5.1453
Dime	1987	2.2998	2.2999	2.2994	2.2999
Dime	1996	2.2538	2.2534	2.2536	2.2544

Table III. continuation

Coin Type	Mint Year ID with mint mark if any.	One Coin (g)	Mass 1 (g)	Mass 2 (g)	Mass 3 (g)
Dime	2012 F	2.2682	2.2678	2.2690	2.2680
Dime	1982 F	2.3122	2.3115	2.3123	2.3123
Dime	2003 P	2.2310	2.2311	2.2312	2.2306
Quarter	1996	5.7298	5.7307	5.7301	5.7302
Quarter	2002 F	5.6962	5.6959	5.6964	5.6962
Quarter	2000 D	5.7004	5.7003	5.7003	5.7007
Quarter	1999 P	5.6654	5.6650	5.6663	5.6653
Quarter	2013 P	5.6873	5.6877	5.6867	5.6879

Table IV. Compared mass one coin (tared boat 0.0000 g) vs same coin weighed three times with weighing boat not tared to 0.0000g

Same Coin	Mint Year ID with mint mark if any.	One Coin (g)	Mass 1 (g)	Mass 2 (g)	Mass 3 (g)	Mean ± g	Difference (g)
Penny	2010	2.5121	4.9346	4.9343	4.9342	4.9344	2.4223
Nickel	2015 D	4.9810	7.4032	7.4025	7.4028	7.4028	2.4218
Dime	1987	2.2998	4.7222	4.7213	4.7215	4.7217	2.4219
Quarter	1996	5.7298	8.1523	8.1516	8.1524	8.1521	2.4223

Table V. Descriptive statistics of US Coins

Cent	Mean Mass (g)	Standard Deviation (g)	% RSD
Penny	2.7507	0.3051	11.09
Nickel	5.0203	0.0648	1.29
Dime	2.2736	0.0307	1.35
Quarter	5.6960	0.0217	0.38

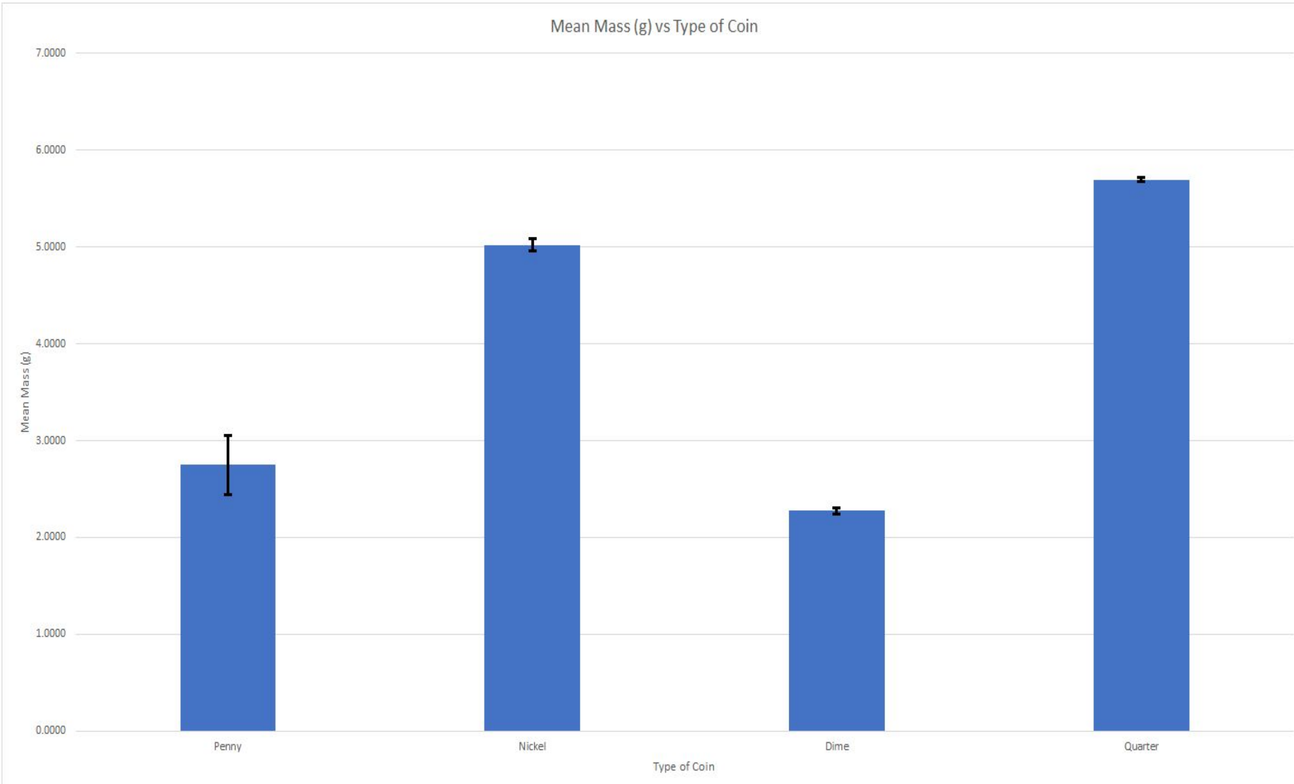

Figure 2. Different masses of US coins with error bars included.

Table VI. Chemical Compositions of US Coins

US Coin	Nickel (%) [2]	Copper (%) [2]	Zinc (%) [2]
Penny	0	2.5	97.5
Nickel	25	75	0
Dime	8.3	91.7	0
Quarter	8.3	91.7	0

IV. Conclusions:

Since the final volume of the water pipetting was assumed to be 25.00mL, the mean mass of the total water in the bottle was 25.1112g. Since the water temperature was 23℃ and the documented density 0.9975 [3] g/mL, the theoretical mass within the bottle should have been 24.9375g. Comparing the documented density to the slope of the graph, the slope signifies the density of the water and it turns out to be 1.0024g/mL. This created a % error of .70%. This .70% error shows that the pipette was decently accurate to deliver the specified amount as well as being decently precise to deliver the 5.00mL of water that was requested each iteration. The accuracy that would be expected if 2.00mL of water was requested would be the same IF the same pipet is being used. If a different pipet is being used, the calibration between two pipettes vary slightly, but that slight amount is enough to change results. Since the introduction of coins, the chemical compositions changed over time. The intercept of the regression line of the graph signifies the expected mean value.

Since 1982, the chemical compositions listed in Table VI are what the pennies are made up of, but before 1982, pennies were primarily made up of copper. For the nickel, the coin has had the same chemical composition throughout the year except during World War II. That was when the composition changed from a nickel copper composition into a silver-copper-manganese alloy. The dime and quarter were made up of 90% silver and 10% copper until 1965. When conducting the coin weighing part of the experiment, the coins were found to be varying in weight dependent on the year they were made. For instance, the penny was found to be heavier in the year of 1982, but after 1982, the penny was about .5000g lighter. The mean mass of the group of five pennies was about 2.7507g, the nickel was 5.0203g, the dime was 2.2736g, and the quarter was 5.6960g. The standard deviation and %RSD for the penny was .3051g and 11.09%, the nickel had a .0648g standard deviation and 1.29 %RSD, the dime had a .0307g standard deviation and a 1.35% RSD, and the quarter had a .0217g standard deviation and a .38 %RSD. If there was a penny on the street, the mass of that penny would be 2.7507±0.1544g. This was calculated at the 95% confidence interval. This means that the penny would lie within the range of 2.5963g to 2.9051g 95% of the time.

V. Miscellaneous Questions from Weighing Lab Procedure:

1. It is important that the balance doors are closed when weighing because if there is any movement in the chamber of the metal pan, the balance can catch it and throw the measurements off.
2. Since each balance can be calibrated differently even though they could be the same model, this is another way to control the experiment.

VI. Miscellaneous Questions from Lab Report Guide:

1. The mean and standard deviation doesn't go past 4 decimal points due to the numbers that are being used only have 4 decimal points of significant figures and anything past the fourth figure is assuming the number instead of having the fourth figure being the inaccurate one.
2. From Figure 1, the equation of the line with slope determines the density of water. The documented density of water at 23℃ is 0.9975 g/mL compared to the slope being 1.0024 g/mL. This yields a difference of .0049 g/mL between the documented and the experimental data.
3. Since the coins are minted from different years, having only one coin being the standard is not the best method. All coins that are still in decent condition can be used so the method that weighs all different kinds of coins and their weights is the better option. This allows for the different chemical compositions of coins throughout the years to be

accounted for the average weight of a specific coin. Both weighing by difference and weighing a tared weighing boat are great methods, but weighing by difference is the better option since if there is variation between the weighing paper or boat and the item to be weighed it can be seen and determined to reduce the amount of error.

4. There are no more than 4 places after the decimal point for mean and standard deviation because the balances only weigh up to four places which means the last digit is uncertain. Another digit after the fourth would mean that the 5th digit is uncertain but the balance(s) used does not back up that information.

VII. References:

1. Undergraduate Instrumental Analysis, James W. Robinson, Eileen M. Skelly Frame, George M. Frame II, CRC Press, 2014, 7th edn.
2. Andy Brunning, The compositions of U.S. coins (Periodic Graphics). Chemical & Engineering News, Vol. 94, p.29, 2016.
3. Roger Walker, Mass, Weight, Density or Specific Gravity of water at various temperatures C and thermal coefficient of expansion of water, 2015.