

Lab 1: An Introduction to Good Analytical Lab Technique

Questions

Part A

Delivery instrument	Sample #	Mass (Analytical Balance, g)	Mass (Top Loading Balance, g)
P-1000	1	1.0037	1.007
	2	1.0106	1.008
	3	1.0168	1.010
10 mL graduated cylinder	1	0.9670	0.900
	2	0.9595	1.008
	3	0.9167	1.049
P-200	1	1.0064	1.030
	2	1.0154	1.034
	3	1.0191	1.030

1.

Delivery instrument	Average density (g/mL) \pm std. dev.	
	Analytical Balance	Top Loading Balance
P-1000	1.0104 \pm 0.0066	1.008 \pm 0.002
10 mL graduated cylinder	0.9477 \pm 0.0271	0.986 \pm 0.077
P-200	1.0136 \pm 0.0065	1.031 \pm 0.002

• P-1000:

▸ Analytical:

$$\text{Average: } \bar{x} = \frac{\sum x_i}{N} = \frac{1.0037 \frac{g}{mL} + 1.0106 \frac{g}{mL} + 1.0168 \frac{g}{mL}}{3} = 1.0104 \text{ g/mL}$$

$$\text{Standard Deviation: } s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{N-1}} =$$

$$\sqrt{\frac{(1.0037 \frac{g}{mL} - 1.0104 \frac{g}{mL})^2 + (1.0106 \frac{g}{mL} - 1.0104 \frac{g}{mL})^2 + (1.0168 \frac{g}{mL} - 1.0104 \frac{g}{mL})^2}{3-1}} = 0.0066 \text{ g/mL}$$

▸ Top-Loading:

$$\text{Average: } \bar{x} = \frac{\sum x_i}{N} = \frac{1.007 \frac{g}{mL} + 1.008 \frac{g}{mL} + 1.010 \frac{g}{mL}}{3} = 1.008 \text{ g/mL}$$

$$\text{Standard Deviation: } s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{N-1}} =$$

$$\sqrt{\frac{(1.007 \frac{g}{mL} - 1.008 \frac{g}{mL})^2 + (1.008 \frac{g}{mL} - 1.008 \frac{g}{mL})^2 + (1.010 \frac{g}{mL} - 1.008 \frac{g}{mL})^2}{3-1}} = 0.002 \text{ g/mL}$$

• 10 mL graduated cylinder:

▸ Analytical:

$$\text{Average: } \bar{x} = \frac{\sum x_i}{N} = \frac{0.9670 \frac{g}{mL} + 0.9595 \frac{g}{mL} + 0.9167 \frac{g}{mL}}{3} = 0.9477 \text{ g/mL}$$

$$- \text{Standard Deviation: } s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{N-1}} =$$

$$\sqrt{\frac{(0.9670 \frac{g}{mL} - 0.9477 \frac{g}{mL})^2 + (0.9595 \frac{g}{mL} - 0.9477 \frac{g}{mL})^2 + (0.9167 \frac{g}{mL} - 0.9477 \frac{g}{mL})^2}{3-1}} = 0.0271 \text{ g/mL}$$

► Top-Loading:

$$- \text{Average: } \bar{x} = \frac{\sum x_i}{N} = \frac{0.900 \frac{g}{mL} + 1.008 \frac{g}{mL} + 1.049 \frac{g}{mL}}{3} = 0.986 \text{ g/mL}$$

$$- \text{Standard Deviation: } s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{N-1}} =$$

$$\sqrt{\frac{(0.900 \frac{g}{mL} - 0.986 \frac{g}{mL})^2 + (1.008 \frac{g}{mL} - 0.986 \frac{g}{mL})^2 + (1.049 \frac{g}{mL} - 0.986 \frac{g}{mL})^2}{3-1}} = 0.077 \text{ g/mL}$$

• P-200:

► Analytical:

$$- \text{Average: } \bar{x} = \frac{\sum x_i}{N} = \frac{1.0064 \frac{g}{mL} + 1.0154 \frac{g}{mL} + 1.0191 \frac{g}{mL}}{3} = 1.0136 \text{ g/mL}$$

$$- \text{Standard Deviation: } s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{N-1}} =$$

$$\sqrt{\frac{(1.0064 \frac{g}{mL} - 1.0136 \frac{g}{mL})^2 + (1.0154 \frac{g}{mL} - 1.0136 \frac{g}{mL})^2 + (1.0191 \frac{g}{mL} - 1.0136 \frac{g}{mL})^2}{3-1}} = 0.0065 \text{ g/mL}$$

► Top-Loading:

$$- \text{Average: } \bar{x} = \frac{\sum x_i}{N} = \frac{1.030 \frac{g}{mL} + 1.034 \frac{g}{mL} + 1.030 \frac{g}{mL}}{3} = 1.031 \text{ g/mL}$$

$$- \text{Standard Deviation: } s = \sqrt{\frac{\sum (x_i - \bar{x})^2}{N-1}} =$$

$$\sqrt{\frac{(1.030 \frac{g}{mL} - 1.031 \frac{g}{mL})^2 + (1.034 \frac{g}{mL} - 1.031 \frac{g}{mL})^2 + (1.030 \frac{g}{mL} - 1.031 \frac{g}{mL})^2}{3-1}} = 0.002 \text{ g/mL}$$

2. The data suggests that the most precise combination was using either the P-200 or the P-1000 with the top-loading balance; with both having a standard deviation of 0.002. The most accurate combination was the P-1000 and the top-loading balance, with the average being 1.008 g/mL, which is 0.011 g/mL away from the true density of water at 21.3°C, 0.997 g/mL (as computed using the table in the lab handout from Table 1.5 R.A. Ray, Jr.; A.L. Underwood. Quantitative Analysis Laboratory

Manual. Prentice-Hall: N.J., 1986.). Thus, the most reliable combination by both metrics is the P-1000 and the top-loading balance.

1. The results for the delivery instruments agrees with what was expected. The 10 mL graduated cylinder was less precise and less accurate since it is not a volumetric tool. The precisions of the P-1000 and P-100 were comparable. An unexpected result of the lab was the top-loading balance outperforming the analytical balance in terms of both accuracy and precision.

Part B

1.

Sample	Weight delivered (g)	Calc. volume delivered (μL)
0	0.4828	482.8
1	0.4942	494.2
2	0.4940	494.0
3	0.4942	494.2
4	0.4953	495.3

According to the manufacturer, the % error of the mean for the P-1000 pipette is 0.8%, which means the range for 500 μL is 496 μL - 504 μL . This does not compare well with the average of the data, 0.4921 μL , indicating the accuracy of the pipette is not within manufacturer specifications. This systemic underestimate of weight may be a result of the extremely dry conditions in the lab causing water to evaporate while in the weigh boat. The manufacturer specifies the standard deviation should be 3.0 μL . This compares well with the experimental standard deviation, 0.0052 μL .

2. To test the contributions of operator error as compared to equipment error, one can repeat the procedure with a different piece of equipment and see if the error remains, or alternately, have a different experimenter repeat the procedure using the same micropipette.

Lab Notebook

Exp. No. 1	Experiment/Subject Introduction to Good Analytical Lab Technique	Date 1/23
Name Nathaniel White	Lab Partner N/A	Locker/Desk No. Course & Section No. Achem

titler Surface
Education ALF203

Pipette: Fisher Brand #19
Volume: 5.00 mL
Temp: 21.5°C
Fisher Brand
Finnipet 2114

A		B	
Volume of 1 mL delivered using	Sample Number	Analytical Balance (g)	Top Loading Balance (g)
P-1000	1	1.0037	1.007
	2	1.0106	1.008
	3	1.0168	1.010
10 mL graduated cylinder	1	0.9670	0.900
	2	0.9595	1.008
	3	0.9167	1.049
P-200	1	1.0064	1.030
	2	1.0154	1.034
	3	1.0191	1.030

Sample	Weight delivered (g)	Calculated Volume delivered (mL)
1	0.4929	492.8
2	0.4942	494.2
3	0.4940	494.0
4	0.4942	494.2
5	0.4953	495.3

Balance: Ohaus Pioneer

Purpose: Determine density of gatorade (A) and calibrate pipette (B)

Procedure: (A) Use different measuring devices ~~and~~ for mass and volume to compare mass of 1 mL gatorade measure

(B) Deliver a consistent volume of water from the pipette and record its mass as determined by an analytical balance

Signature Nathaniel White	Date 1/23	Witness/TA Andresa Lima	Date
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THE HAYDEN-McNEIL STUDENT LAB NOTEBOOK

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