Food Explorations Lab I:

Mastering Measurements

STUDENT LAB INVESTIGATIONS

Name: ____

Lab Overview

During this investigation, you will be asked to measure substances using household measurement tools and scientific measuring tools. You will compare the values you obtain to the expected values and calculate percent error. Relative densities of measured substances will also be compared.

Lab Objectives

In this lab, you will learn how to…

1. Identify measurement tools for mass and volume.

2. Properly use measurement tools to obtain accurate measurements.

3. Identify measurement tools that provide the most precise measurements.

4. Identify factors that can impact the accuracy of a measurement.

5. Use mass and volume measurements to compare relative densities of the measured substances.

You will work in a group to perform a series of measurements. The goal of the investigation is to identify measurement tools, learn precise methods of measurement, and identify factors that can impact accuracy.

Lab Safety: Before beginning ANY investigation you should put on your safety goggles and apron. Always wash your hands following completion of an investigation. When handling food, you should also wash your hands prior to beginning an investigation.

Lab Questions

1. Which of the methods below will produce the most accurate measurement for the dry ingredient flour? (Circle your answer.)

Spooned Method

Dipped Method

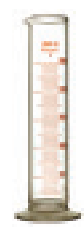
Sifted Method

Prediction #1: I predict the ______________________________ method will provide the most accurate measurement of flour because…

2. Which of the below tools will produce the most precise measurement for liquid ingredients? (Circle your answer.)

Liquid Measuring Cup
(Cups and Fluid Ounces)

Dry Measuring Cups
(1 cup, ¾ cup, ½ cup, ¼ cup)



Graduated Cylinder
(mL)

Prediction #2: I predict the ______________________________ will provide the most precise measurement of liquid ingredients because…

Observation of Measurement Types & Accuracy

MATERIALS

Assignment A – Method Accuracy
1 ½ cups flour in a plastic bag
1 set dry measuring cups
1 triple beam balance
1-2 sheets wax paper
1 strainer (wide mesh)
1 medium bowl
1 plastic knife
1 plastic spoon

Assignment B – Tool Precision
1 cup cooking oil in a plastic cup
1 cup water in a plastic cup
1 set dry measuring cups
1 liquid measuring cup
1 graduated cylinder
1 triple beam balance

Obtain your assignment from you teacher. Record your group's assignment below.

My group's assignment is: ____

ASSIGNMENT A: PROCEDURE

MEASUREMENT METHOD ACCURACY - WEIGHING & MEASURING DRY INGREDIENTS

Use three different methods to measure ½-cup of flour: **Dipped Method**, **Sifted Method**, and **Spooned Method**.

1. Before you begin, place the ½-cup dry measuring cup on your balance. Using the balance, find the mass of the measuring cup.

Mass of ½-cup Measuring Cup = ________________________**g**

2. Measure flour using the **Dipped Method**:

   a. Dip the ½-cup dry measuring cup directly into the container of flour, filling it to overflowing with flour.

   b. Level with the flat edge of a plastic knife over wax paper and mass the cup plus flour on the balance. Calculate the mass of the flour as follows:

   Mass of Flour = Mass of Cup and Flour – Mass of Cup

   c. Record the volume (cups) and mass (grams) of flour in Table A under the "Mass in grams" column.

   d. Place the flour back into the plastic bag.

3. Measure flour using the **Spooned Method**:

a. Stir the flour in a medium bowl or the bag with a spoon.

b. Spoon flour gently into a ½-cup dry measuring cup. Level with the flat edge of a plastic knife over wax paper and mass the cup plus flour on the balance. Calculate the mass of the flour as follows:

Mass of Flour = Mass of Cup and Flour – Mass of Cup

c. Record the volume (cups) and mass (grams) of flour in Table A under the "Measured Mass (grams)" column.

d. Place the flour back into the plastic bag.

4. Measure flour using the **Sifted Method**:

a. Measure ½ cup of flour using the ½-cup dry measuring cup.

b. Pour the flour into a strainer (½ cup).

c. Sift onto wax paper by gently tapping the strainer against the palm of your hand.

d. Spoon flour gently into the ½-cup dry measuring cup. Level with the flat edge of a plastic knife over wax paper and mass the cup plus flour on the balance. Calculate the mass of the flour as follows:

Mass of Flour = Mass of Cup and Flour – Mass of Cup

e. Record the volume (cups) and mass (grams) in Table A.

f. Place the flour back into the plastic bag.

5. Share your data with the other student groups to complete Table B.

Table A: Dry Ingredient Measurements

Method	Measured Volume (cups)	Measured Mass (grams)
Sifted Flour	$\frac{1}{2}$ cup	57g
Spooned Flour	$\frac{1}{2}$ cup	59g
Dipped Flour	$\frac{1}{2}$ cup	62g

6. Using the *Common Weights and Measures* chart, calculate the actual flour mass (grams) per ½ cup (volume):

$$\frac{115g \text{ per cup}}{2} = 57.5g \text{ per } \tfrac{1}{2} \text{ cup}$$

ASSIGNMENT B: PROCEDURE

MEASUREMENT TOOL PRECISION - WEIGHING & MEASURING LIQUID INGREDIENTS

Use the following steps to measure ¼ cup of water and cooking oil using three types of measurement tools: **Liquid Measuring Cup**, **Graduated Cylinder**, and **Dry Measuring Cup.**

1. Before you begin, measure the mass of your liquid measuring cup and record its mass below.

   Mass of Liquid Measuring Cup: ____________ grams. This mass will need to be subtracted from the mass of the liquid.

2. Next, place the dry measuring cup on your balance and record its mass below.

   Mass of Dry Measuring Cup: ____________ grams. This mass will need to be subtracted from the mass of the liquid.

3. Next, place the graduated cylinder on your balance and record its mass below.

   Mass of Graduated Cylinder: ____________ grams. This mass will need to be subtracted from the mass of the liquid.

4. Measure water using three types of measuring tools:

   a. Place the liquid measuring cup on a level surface.

   b. Measure out ¼ cup of water in the liquid measuring cup. Be sure to take the ¼ cup measurement at the lowest point of the meniscus (curved upper surface of the liquid).

   c. Mass the water.

   Mass of Water = Mass of Water and Cup – Mass of Cup

   d. Record the volume (ounces) and mass of the water in the column labeled "Water Volume" in Table B.

   e. Repeat steps a through d using a dry measuring cup.

   f. Repeat steps a through d using a graduated cylinder.

5. Measure cooking oil using three types of measuring tools:

   a. Place the liquid measuring cup on a level surface.

b. Measure out ¼ cup of cooking oil in the liquid measuring cup. Be sure to take the ¼ cup measurement at the lowest point of the meniscus (curved upper surface of the liquid).

c. Mass the cooking oil.

Mass of Oil = Mass of Oil and Cup – Mass of Cup

d. Record the volume (ounces) and mass of the cooking oil in the column labeled "Oil Volume" in Table B.

e. Repeat steps a through d using a dry measuring cup.

f. Repeat steps a through d using a graduated cylinder.

6. Share your data with the other student groups to complete Table B.

Table B: Liquid Ingredient Measurements

Measuring Tool	Water Volume (ounces)	Water Mass (grams)	Oil Volume (ounces)	Oil Mass (grams)
Liquid Measuring Cup		67.3g		56.5g
Dry Measuring Cup		57.3g		52.7g
Graduated Cylinder		59.3g		52.3g

Use the *Common Weights and Measures* chart to complete 7-8.

7. Calculate the actual water mass (grams) per ¼ cup (volume):

$$\frac{236.5\text{g per cup}}{4} = 59.1\text{g}$$

8. Calculate the actual oil mass (grams) per ¼ cup (volume):

$$\frac{210\text{g per cup}}{4} = 52.5\text{g}$$

Calculation of Accuracy:

1. Using the *Common Weights and Measures* chart, calculate the % error in Tables B and D.

Example:

First determine the actual mass of your ingredient per ½ cup (volume). Flour masses 115g per cup. Let's say you massed 1 cup of spooned flour and it was 120 grams. To find percent error, subtract 115g (actual flour mass) from 120g (spooned flour mass). Your error is 5g.

To find percent error, divide your 5 grams (error) by your spooned flour measure of 120 grams (5g ÷ 115g = 0.04). Then, multiply that value by 100 (0.04g × 100 = 4%). Your percent error is 4%.

$$|120g - 115g| = 5g$$

$$\frac{5g}{115g} = 0.04$$

$$0.04 \times 100 = 4\%$$

Table C: Dry Ingredient % Error Calculation

Method	Calculations	% Error
Sifted Flour	$\lvert 57g - 57.5g \rvert = 0.5g$ $\frac{0.5g}{57.5g} = -0.009$ $0.009 \times 100 = 0.9\%$	0.9%
Spooned Flour	$\lvert 59g - 57.5g \rvert = 1.5g$ $\frac{1.5g}{57.5g} = 0.026$ $0.026 \times 100 = 2.6\%$	2.6%
Dipped Flour	$\lvert 62g - 57.5g \rvert = 4.5g$ $\frac{4.5g}{57.5g} = 0.078$ $0.078 \times 100 = 7.8\%$	7.8%

Table D: Liquid Ingredient % Error Calculations

Method	Water Calculations	Water % Error	Oil Calculations	Oil % Error
Liquid Measuring Cup	$\lvert 67.3g - 59.1g \rvert = 8.2g$ $\frac{8.2g}{59.1g} = 0.139$ $0.139 \times 100 = 13.9\%$	14.0%	$\lvert 55.6g - 52.5g \rvert = 3.1g$ $\frac{3.1g}{52.5g} = 0.06$ $0.06 \times 100 = 6.0\%$	6.0%
Dry Measuring Cup	$\lvert 57.3g - 59.1g \rvert = 1.8g$ $\frac{1.8g}{59.1g} = 0.03$ $0.03 \times 100 = 3.1\%$	3.1%	$\lvert 52.7g - 52.5g \rvert = 0.2g$ $\frac{0.2g}{52.5g} = 0.004$ $0.004 \times 100 = 0.4\%$	0.4%
Graduated Cylinder	$\lvert 59.3g - 59.1g \rvert = 0.2g$ $\frac{0.2g}{59.1g} = 0.003$ $0.003 \times 100 = 0.3\%$	0.3%	$\lvert 52.3g - 52.5g \rvert = 0.2g$ $\frac{0.2g}{52.5g} = 0.004$ $0.004 \times 100 = 0.4\%$	0.4%

2. Using the % error, determine which measurement method was the most accurate for measuring flour. Why did they differ? Which method masses the most, which masses the least?

The sifted ½ cup of flour yielded the most accurate measurement. The Common Weights and Measures chart stated 1 cup of flour should equal 115g per cup. The sifted ½ cup of flour weighed approximately 57g per ½ cup, or 114 grams per cup. In addition, the percent error of the sifted flour was calculated to be 0.9%, the least of the 3 methods. The spooned flour was the next most accurate method of measurement.

3. If 1 cup of sifted flour has a mass of 77 grams, and 1 cup of dipped flour has a mass of 3 ¾ ounces, which has a greater mass? Explain the mass difference.

The dipped flour weighs more because air is now present in the sifted flour increasing the volume while decreasing the mass. There are approximately 28.35 grams in one ounce, so 77 grams is equal to about 2 ¾ ounces of flour. Dipped flour masses the most. Sifted flour massed the least. This is because when flour is sifted or spooned, it becomes less dense. The dipped flour has a greater mass.

4. Which measurement tool (dry versus liquid measuring cup) was the most precise for measuring cooking oil and water? Explain why the tools would yield different results.

The liquid measuring cup was the most precise because it allows the oil to be poured to exactly the right amount. The dry measuring cup does not allow you to measure the exact amount without spilling oil.

5. Explain why equal volumes of cooking oil and water would have different masses. Which liquid has the greater density?

   Equal volumes of cooking oil and water would have different masses because of differences in density. Water is more dense than oil.

6. Infer the affect sifting has on the measured flour's density. Explain why.

   Sifting forces air molecules in place of flour molecules resulting in a decrease in the flour's density because air weighs less than flour.

7. If you need ½ a gallon of water, but only had a four-cup liquid measure, how many cups would you need to use? How many tablespoons? How many fluid ounces? Use the Common Weights and Measures chart as a guide.

   Cups: 2

   Tablespoons: 16 tablespoons x 4 cups x 2 cups = 128tbsp

   Fluid Ounces: 8 fluid ounces x 4 cups x 2 cups = 64oz

8. If you are making zucchini muffins (several times the recipe) for a bake sale at school, how would you measure your dry ingredients (e.g. flour)? Liquid ingredients (e.g. cooking oil)? Why? (*HINT:* What measurement methods were the most accurate? Which measurement tool(s) were the most accurate?)

   Dry Ingredients: These should be measured using dry measuring cups if the recipe calls for volumetric amounts. When measuring flour, the sift method should be used. If the recipe calls for weight, these should be measured using a scale.

   Liquid Ingredients: These should be measured using a graduated cylinder.

9. Apart from the tools and methods used, what other factor(s) may have impacted your ability to obtain accurate measurements?

   Human error (e.g. spilling liquid), precision of measurement instrument (may vary by manufacturer), accuracy of method used, and use of measurement tools that will hold greater quantities than being measured (e.g. using a 1 cup measure to measure $\frac{1}{2}$ cup).

10. In your own words, describe why it is important for scientific measurement tools to be precise and be used properly to give accurate measurements.

    (Multiple answers possible)

    It is important for scientific measurement tools to be precise and be used properly because there is little room for error in science. For example, one small difference when mixing chemicals can lead to injury or an incorrect result.