Lab 1: Measurement: Accuracy and Precision

Lab Materials:
Rulers
Non-programmable calculator
1 Sheet of notebook paper
Scissors
Stopwatch
Kitchen Balance (measures to nearest 1g)
Plastic cups
Measuring spoons
Water

Name: ____________________________ Date: _____________

Measurement: Accuracy and Precision

When scientists collect data, they must determine the accuracy and precision of their measurements. Accuracy refers to how close the measured quantities are to the actual or true value. Precision refers to the closeness of each of the data sets to one another. To distinguish between these two terms, it is useful to think of a target and the position of the measurements on the target. If the measurements are clustered together but away from the center of the target, then we would say the measurements are precise, but not accurate. If the data hits the center on the target, the measurements are precise and very accurate, i.e. the values collected are close to the true value one should obtain. In today's lab, you will make measurements and perform calculations to the appropriate number of significant figures. You will then determine if your measurements are precise and/or accurate. Before doing this though, you will have several exercises that test your knowledge of significant figures.

Significant Figures

In any given measurement, non-place holding digits are referred to as significant digits or most often "sig figs" (for significant figures). The greater the number of sig figs, the greater the precision in the measurement. To determine the number of significant figures in a given quantity, follow these rules:

1. All nonzero numbers are significant.
2. Zeroes located between two numbers are significant.
3. Zeroes located <u>after</u> a decimal point are significant
4. Zeroes located to the left of the first nonzero number are NOT significant; therefore, the number 0.002 has only 1 significant figure since the 3 zeroes prior to the number 2 are serving only as place holders.
5. Zeroes located at the end of a number but <u>before</u> a decimal point are ambiguous. For instance, we cannot determine the number of sig figs in say, 6350. To avoid this confusion, we either write 6350**.** or 6.350×10^3 to indicate that the zero is significant.
6. Exact numbers (numbers obtained from counting or numbers originating from defined quantities, such as 12 inches = 1 foot) have *infinite* number of significant digits.

1. For the following examples, determine the number of significant figures.

   a. 4762 __________

   b. 902 __________

   c. 0.0000438 __________

   d. 987,000,000,000 __________

   e. 0.000834 __________

f. 4.32×10^4 __________

g. 9.2735×10^{-5} __________

h. 6,049,071 __________

i. 678.20 __________

j. 903,089,932,000. __________

Significant Figures in Calculations

One important concept to remember when you perform mathematical calculations is that the answer you report must reflect the precision in the quantities you measured. Your answer should not show more precision that what you were capable of measuring; therefore, **when doing mathematical calculations, there should not be a gain or loss in precision.**

The rules to follow for determining the number of significant figures depends on the type of mathematical operation you are performing.

<u>Multiplication and Division</u>

The reported answer should carry the same number of significant figures as the quantity with the *fewest* number of significant figures.

<u>Addition and Subtraction</u>

The reported answer should carry the same number of *decimal places* as the quantity with the *fewest* decimal places.

When performing these calculations, it will most likely be necessary to round your final answer to the appropriate number of significant figures. To round your answer, look for the left-most digit being dropped. If this digit is four or less, round your answer down; however, if this digit is 5 or greater, round your answer up.

****Important Note**** For calculations involving <u>both</u> multiplication/division <u>and</u> addition/subtraction, do NOT round your answer in intermediate steps. Determine the number of significant figures in <u>each</u> step, but use the entire answer from each step in later steps. ALWAYS round your FINAL answer, NOT the intermediate answers.

2. For each of the following, report your answer to the correct number of significant figures.

a. $20.76 \times 4.89 \times 1.2$ __________

b. 15.67 – 0.789 + 9.5 __________

c. (3,789 – 2,569)/2.5 __________

d. 7.94 – 3.25 x 2 __________

e. 3,789 – 2,569/2.5 __________

Measurements

3. Below are data sets from three students who were measuring the length of a piece of string.

Student A:	Student B:	Student C:
8.2 cm	5.2 cm	6.1 cm
8.4 cm	3.4 cm	5.9 cm
7.9 cm	7.2 cm	6.2 cm

a. The true length of the string is 6.2 cm. Which student(s) measurements is/are accurate?

b. Which student(s) measurements is/are precise?

c. Are any of the students' measurements both precise and accurate? Please explain.

4. Length[1]

a. Fold a piece of notebook paper into eight uniform rectangles, and then cut them out. Take one of the rectangles and using a best guess, try drawing a 6.5 cm line on it **without** using any measuring device. Set this paper aside. Without looking at this piece of paper, try drawing another 6.5 cm line on 3 more rectangles. Now, using a ruler, measure the exact length of each of your lines to the appropriate number of sig figs, and record them in the table below.

	Measured Length, cm
Trial 1	
Trial 2	
Trial 3	
Trial 4	

b. Calculate the average of your results. To receive credit, you must show your work.

c. What is your percent error? Show your work.

d. Comment on the accuracy and precision of your measurements.

e. On the remaining 4 rectangular pieces, try again to draw a 6.5 cm line on each of them. Again, do not use any measuring device when drawing the lines and do not refer to previous drawings. When you have finished, again measure the actual length of the lines and record your results in the table below.

	Measured Length, cm
Trial 1	
Trial 2	
Trial 3	
Trial 4	

f. What is the average and percent error of your measurements? Again, work must be shown to receive credit.

g. How do your results compare to your first set of measurements? Which set is more accurate? More precise? Please explain.

5. Time[1]

a. Using a stopwatch, close your eyes, and try to estimate the passing of 30 seconds. Record the actual time that has passed in the table below. Repeat this 3 more times.

	Measured Time, s
Trial 1	
Trial 2	
Trial 3	
Trial 4	

b. What is the average and percent error of your measurements?

c. Did your accuracy improve with subsequent trials?

6. Surface Area

Choose any regular shaped object (your desk, a table, your textbook) and calculate the surface area in cm^2. Record each individual measurement below and show a calculation of the surface area. Make sure your measurements and answers are to the appropriate number of significant figures.

7. Mass
Obtain a plastic cup, kitchen balance, and measuring spoon. When using a balance, please follow these general guidelines:

  1. Always make sure the balance reads zero before and after you make a measurement. Use the "Tare" button to zero the balance before you place the object/chemical on the balance.
  2. To obtain an accurate measurement, always make sure the item you are measuring is at room temperature.
  3. NEVER place any chemical directly on the balance. It should always be in the container specified in the lab procedure. If none is specified, then a plastic cup can be used.

Record the following measurements. Do NOT empty any of the water out of your cup in between readings, and only tare the balance prior to obtaining your first measurement in part a below.

a. Mass of plastic cup, g ____________

b. Mass of 1 tablespoon of water, g ____________

c. Mass of 2nd tablespoon of water, g ____________

d. Mass of 3rd tablespoon of water, g ____________

e. Average mass of a tablespoon of water, g ____________
(Show work)

f. Greatest difference of 3 masses (largest mass – smallest mass) ____________
(Show work)

g. Knowing that 1 tablespoon = 14.79 mL (milliliters), what is the density (D) of water at room temperature? Please note that density is equal to mass/volume and has units of g/mL.

Reference:
[1]Author Unknown,
http://www.sciencebyjones.com/PDF%20files/accuracy%20and%20precision%20home%20lab%2020 04%20PDF%203.pdf, accessed Aug. 17, 2009.