PRECISION AND ACCURACY

When working with tools of measurement we need to be able to interpret the value of the measurement the devise has given. In other words we need to be able to determine the "correctness" of the answer we derive from the tool. We have often heard people comment that the doctor's office scale must be wrong, it's reading too heavy. In a lab situation we need to ask our selves, is our lab equipment measuring properly and if not how is it wrong?

In order to answer these questions it is important to test your equipment with standards. Standards are substances that have known values. For example, one might test a scale with a known 100 gram weight. If the scale reads 100 grams each time the weight is placed on it then we know the scale is working properly. If the scale does not always read 100 grams then we need to investigate what type of problem there maybe.

When the same value results from repeated measurements, the measurements are said to be **precise**. An instrument can have high precision regardless of how close the measurements are to the accepted value. Precision can be more clearly defined as the measure of the agreement between two or more measurements that have been made by the same method. If an instrument gives a variety of answers but they are all fairly close to the correct answer, it is said to be **accurate.** We can then define accuracy as an indication of how close a measurement is to its accepted value.

Let us think of an archer; he may not hit a bulls eye but is able to locate three arrows fairly close to center, but not replicate the same location, he would be said to be accurate. However, if the archer was to shoot his bow and deliver all three arrows to the same location he would be precise, but not necessarily accurate.

Depending on whether our instrument is accurate or precise will determine the method used to correct the error. You will need to be able to state whether an instrument is accurate or precise, and later tell the percentage of the error.

- For example, Two students weighed the same sample on two different balances. The results were as follows:

Balance A	Balance B
12.11g	12.1324g
12.09g	12.1322g

If asked which balance is more precise, the answer would be balance B. Balance B is able to repeat the same mesurement. However if the actual mass of the sample is 12.1g, which balance is more accurate? Balance A would be considered more accurate as its readings are closer to the accepted value.

Practice: Determine whether the following are accurate, precise or both.

Student 1: 72.75 g, 73.34 g, 73.02 g, 73.25 g

Student 2: 72.01 g, 71.99 g, 72.00 g, 71.98 g

1. Which student's measurements are more precise?

2. If the actual mass of the sample is 71.95g, which student's measurements are more accurate?

PERCENT ERROR

Often times in lab we will have to determine the percent of error in a measurement. In order to calculate percent error you **must** know the accepted or actual value. To find percent error, the difference between your value and the accepted value is divided by the accepted value, then multiplied by 100%.

$$\text{Percent error} = \frac{|\text{your value} - \text{accepted value}|}{\text{accepted value}} \times 100\%$$

When performing this calculation an absolute value is given, that is to say neither positive or negative.

- For example, the accepted density of corn syrup is 1.38g/cm^3. A student measures the value to be 1.25g/cm^3.
  $\frac{|1.25 - 1.38|}{1.38}$ x 100% = 9.42% error
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Practice: Determine the percent error for the following problems.

1. The known mass of a sample is 5.00g but on our scales we measure the mass as 5.02g.

2. A student determined the atomic mass of aluminum to be 28.9, but the accepted value is 26.98.

3. An experiment yields the density of lead as 10.95 g/cm^3. The actual density of lead is 11.342 g/cm^3.

RATIOS

Many times a value is a combination of measurements, for example we speak of speed as miles per hour (mph). This combination of values is actually a ratio. **Ratios** are another way of expressing results by comparing two items. In our day to day life we may use ratios to compare price to amount of product, $1.99/pound or $2.50 for a 12 pack of soda. When we use ratios we can make comparisons between two like products.

- For example: If Coke was $6.99 for a 24 pack of soda but Pepsi was on sale for $2.50 for a 12 pack, we can use these ratios to determine the best buy.
  To complete this decision we must set up ratios.
  Coke = $6.99/24 cans = $0.29/can
  Pepsi = $2.50/12 cans = $0.21/can
  From these ratios we can see that Pepsi is a better buy.

In science we also use ratios to express measurements. Speed, as we said earlier, is a ratio of distance per time. Density is also a ratio (mass per volume). We will use ratios throughout the year in conversions and dimensional analysis.

Practice: Use ratios to determine which of the following is a better buy.

1. Brand A detergent costs $5.00/10 oz. Brand B detergent costs $6.00/16 oz.

2. One dozen eggs costs $1.01 Eighteen eggs sell for $1.42

3. A single pack of popcorn can be purchased for $1.05, and a three pack of popcorn can be purchased for $3.75.

Name: ____ Period: ___ Date: ______________________

Homework: Precision, Accuracy, Percent Error and Ratios

Define the following:

1. Precision:

2. Accuracy:

Complete the following problems using your understanding of precision and accuracy.

1. Which of the following student's data is precise?
   Student 1:
   72.75 g, 73.34 g, 73.02 g, 73.25 g
   Student 2:
   72.01 g, 71.99 g, 72.00 g, 71.98 g

2. The correct value for the length of a metal rod is 22.6 cm. Which of the following sets of data of this rod could be considered precise but not accurate?
   a. 22.5 cm, 22.7 cm, 22.6 cm
   b. 12.6 cm, 22.6 cm, 32.6 cm
   c. 20.4 cm, 20.2 cm, 20.5 cm
   d. 24.6 cm, 23.7 cm, 25.9 cm

3. For the above sets of data which would be the most accurate?

Calculate the percent error for the following problems.

1. An experiment performed to determine the density of lead yields a value of 10.95 grams per cubic centimeter. The literature value for the density of lead is 11.342 grams per cubic centimeter.

2. The boiling point of bromine was measured as 40.6°C. the accepted value for the boiling point of bromine is 59.35°C.

3. A student measured the length of a metal rod and recorded it as 25.32 cm. The actual length of the rod is 25.50 cm.

4. A student measured the mass of a beaker on scale A. He recorded the mass as 47.01 g. A second student measured the same beaker on scale B. The second student recorded a mass of 46.88 g. The actual mass is 47.00 g. Calculate the percent error for both scales and determine which scale is most accurate.

Using your knowledge about ratios, please complete the following problems.

1. If Brand A soda was on sale for $6.25 for a 24 pack and Brand B soda was on sale for $1.99 for a 6 pack. Which soda is a better buy?

2. Jane went to the store and bought 5 pounds of hamburger for $6.89. How much did she pay per pound?

3. If a the speed limit is 55 mph between two cities that are 72 miles apart, how long would it take to make the drive?

4. How many grams would a gold nugget weigh if its volume is 44.58 cubic centimeters? (the density of gold is 102.98 grams per cubic centimeter)