Physics 181
Spring 2020
Exam 1 Review

Rounding

Two conditions:

1.) First non-zero value is a 1, second non-zero value is less than five – answer will keep two non-zero values

$$\pm 0.013578 \longrightarrow \pm 0.014$$

2.) First non-zero value is a 2 or greater – answer will keep one non-zero value

$$\pm 0.001734 \longrightarrow \pm 0.02$$

Error Propagation

Let *q* be a function of variables *x,y,z*

1.) Additive Rule

For an equation of the following form:

$$q = x + y + z$$

Or

$$q = x - y - z$$

The error on the function *q* is

$$S_q = \sqrt{(S_x)^2 + \left(S_y\right)^2 + (S_z)^2}$$

2.) Multiplicative Rule

For an equation of the following form:

$$q = x^l * y^m * z^n$$

Or

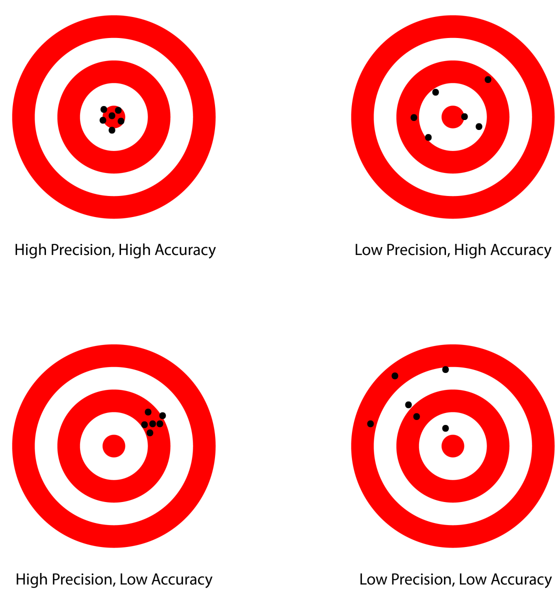
$$q = x^l \div y^m \div z^n$$

The error on the function *q* is

$$S_q = |q| \sqrt{\left(l \frac{S_x}{x}\right)^2 + \left(m \frac{S_y}{y}\right)^2 + \left(n \frac{S_z}{z}\right)^2}$$

Types of Error

1.) Random Error – reduce precision of data and introduces a spread to your data.
   a. Quantified by standard error
   b. To minimize, take more measurements
2.) Systematic Error – reduces accuracy of data and introduces a shift to your data.
   a. Quantified by percent difference
   b. To minimize, analyze what could be introducing these errors & fix during the next experimental test
3.) Reading Error – quantifies to what precision you can take measurements based on your experimental apparatus.
   a. In general – reading error for an instrument is lowest incremental value given by instrument divided by 2



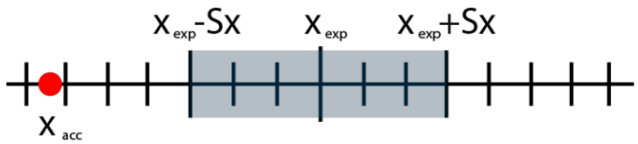
Precision vs. Accuracy Test

Test to see if there is a significant contribution from systematic errors in your experiment.

$$|x_{experimental} - x_{accepted}| > or < S_x$$

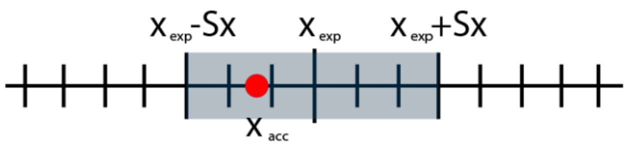
1.) Case 1: The absolute value of the difference is greater than the standard error. Systematic errors dominate and the cause needs to be evaluated. Hence, your results are not accurate.

$$\left|x_{experimental} - x_{accepted}\right| > S_x$$



2.) Case 2: The absolute value of the difference is less than the standard error. Systematic errors are negligible (but not zero!). Hence, your results can be considered accurate.

$$\left|x_{experimental} - x_{accepted}\right| < S_x$$



Linear Regression

When performing 2D stats, we make an assumption that the relationship between the independent and dependent variables is linear.

1.) R^2 will give the correlation coefficient between the independent and dependent variables when fitting any data to a linear graph (only in this class! Not all functions are linear).
   a. R^2 about equal to 1 signifies a good fit of the data
   b. The lower the value of R^2, the less likely you are to have a decent fit of your model to your data. Your data does not have a linear dependence.

Key Topics Tested

1.) Using Excel for data analysis and manipulation
2.) Understanding and utilizing introductory statistics concepts. What do each of the following items represent/mean physically?
   a. Error associated with a measurement
   b. Average
   c. Standard Deviation
   d. Standard Error
3.) Recognizing types of errors. What is the difference between systematic and random error? How do each type manipulate your data set?
4.) Understanding the difference between precision and accuracy.

5.) Understanding when to use 1D or 2D stats. What assumptions need to be made ahead of time for us to use 2D stats? How can we use linearization to our advantage in the presence of a non-linear relationship? Namely, what do these terms represent, and what units will they have in relationship to the units of each axis?
    a. Slope
    b. Intercept
6.) What does R^2 represent? Without looking at a physical graph, what does this value tell us about the characteristics of our graph and the relationship between the dependent and independent values?

Tips for Studying

1.) Redo each pre-lab with closed notes. Ensure you know how to do each one correctly.
2.) Revisit each lab handout. What are the key ideas for each experiment?
    a. What are we quantifying in each lab? What are we solving for?
    b. How did we use the lab equipment to reach our goal? What type of equipment was used for each experiment (timers, graduated cylinder, Vernier caliper, etc.)
    c. What data did we need to take (mass, volume, etc.)?
    d. What were the main formulas we used to manipulate our data?
    e. How did we propagate error?
    f. How did we relate our variables to each other (for example, what did we plot and what information can we extract from our plot?)
3.) Review the Questions section for each lab. Make sure you understand how to solve each one correctly, as you will be required to show all work on an exam.

Experiments Covered

1.) Density of Unknown Metal
2.) Density of Water
3.) Speed of Sound
4.) Kinematics of Free Fall