Error Analysis for Physics 2A
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In physics 2A experiments, the students are expected to analyze the results of their experiments and conclude whether the hypothesis has been substantiated – meaning an experimental result is close to the theoretical calculation. Exact agreement is rarely attained; there are instrumentation errors or errors in the modeling (i.e., the application of physical principles). Invariably there are discrepancies between the theoretical (modeled) result and the experimental (observed) result. So we shall discuss what to consider when analyzing the discrepancies. In what follows, I will assume that you, the student have obtained at least four results or individual measurements.

Modeling or Application of Principles Errors

Often in doing experiments in physics 2A, we shall assume that air resistance and friction can be ignored. In some experiments strings and springs are assumed to have negligible mass. These assumptions allow us to develop relatively simple expressions for the outcome. However, when you analyze the results of an experiment and compare those results to a theoretical model, you need to consider whether some of these factors, which were not in the theoretical calculation, are contributing to the observed discrepancy.

Measurement Errors

There are two types of errors –

- Random Errors – These are errors due to random events, which can be averaged out over many trials. An example of such an error would be reading the mass on a balance scale. Where you judge the scale to balance will have some random errors associated with it.
- Systematic Errors – These are errors that are due to the instrument in use having reproducible but repeatable errors. People often complain that their gas gauges are inaccurate. They read high until they are close to empty and then the needle moves down quickly. Assuming this is correct, this would be an example of a systematic error.

Analysis of Random Errors

For this class, we will use a relatively simple formula for analyzing random errors. First, you must calculate the mean (m) , standard deviation (SD), and standard error (SE) of a sequence of results. Excel or graphing calculators can be used to calculate the mean and standard deviation. The standard error is simply the standard deviation divided by the square root of the number of trials ($SD/\sqrt{N} = SE$)* .

We calculate the t-statistic given by:

$\left|\frac{m-r}{SE}\right| = t$ where m is the mean of the measurement and r is the reference value

At the 95% confidence level, which will be the common criterion for our labs, the t-statistic should be less than 2.02 for six results, 2.13 for five results, and 2.35 for four results. For greater than six results, use 2.00. If the t- statistic is larger than these values, something besides random errors has contributed to the discrepancy.

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*SD is calculated by the TI-83/4 by using the S_x statistic generated by the 1-Var Stat Application. Excel calculates it using the "STDEV" function. $SD = \sqrt{\sum (x_i - m)^2 / (N-1)}$