

Keeping a Laboratory Notebook

Unit: Laboratory & Measurement

NGSS Standards: N/A

MA Curriculum Frameworks (2006): N/A

AP Physics 2 Learning Objectives: SP 4.3

Knowledge/Understanding:

- rules for recording and working with laboratory procedures and data

Skills:

- Ensure that essential information is recorded properly during an experiment.

Language Objectives:

- Understand and be able to describe the sections of a laboratory notebook write-up, and which information goes in each section.

Notes:

A laboratory notebook serves two important purposes:

1. It is a legal record of what you did and when you did it.
2. It is a diary of exactly what you did, so you can look up the details later.

Your Notebook as an Official Record

Laboratory notebooks are kept by scientists in research laboratories and high tech companies. If a company or research institution needs to prove (perhaps in a court case) that you did a particular experiment on a particular date and got a particular set of results, your lab notebook is the primary evidence. While there is no right or wrong way for something to exist as a piece of evidence, the goal is for you to maintain a lab notebook that gives the best chance that it can be used to prove beyond a reasonable doubt exactly what you did, exactly when you did it, and exactly what happened.

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Recording Your Procedure

Recording a procedure in a laboratory notebook is a challenging problem, because on the one hand, you need to have a legal record of what you did that is specific enough to be able to stand as evidence in court. On the other hand, you also need to be able to perform the experiment quickly and efficiently without stopping to write down every detail.

If your experiment is complicated and you need to plan your procedure ahead of time, you can record your intended procedure in your notebook before performing the experiment. Then all you need to do during the experiment is to note any differences between the intended procedure and what you actually did.

If the experiment is quick and simple, or if you suddenly think of something that you want to do immediately, without taking time to plan a procedure beforehand, you can jot down brief notes during the experiment for anything you may not remember, such as instrument settings and other information that is specific to the values of your independent variables. Then, as soon as possible after finishing the experiment, write down *all* of the details of the experiment. Include absolutely *everything*, including the make and model number of any major equipment that you used. Don't worry about presentation or whether the procedure is written in a way that would be easy for someone else to duplicate; concentrate on making sure the specifics are accurate and complete. The other niceties matter in laboratory reports, but not in a notebook.

Recording Your Data

Here are some general rules for working with data. (Most of these are courtesy of Dr. John Denker, at <http://www.av8n.com/physics/uncertainty.htm>):

- Keep all of the raw data, whether you will use it or not.
- Never discard a measurement without writing it down, even if you think it is wrong. Record it anyway and put a "?" next to it. You can always choose not to use the data point in your calculations (as long as you give an explanation).
- Never erase or delete a measurement. The only time you should ever cross out recorded data is if you accidentally wrote down the wrong number.
- Record all digits. Never round off original data measurements. If the last digit is a zero, you must record it anyway!

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- For analog readings (*e.g.*, ruler, graduated cylinder, thermometer), always estimate and record one extra digit beyond the smallest marking.
- Always write down the units with every measurement!
- Record every quantity that will be used in a calculation, whether it is changing or not.
- Don't convert units in your head before writing down a measurement. Always record the original data in the units you actually measured it in, and then convert in a separate step.
- Always record uncertainty separately from the measurement. Never rely on "sig figs" to express uncertainty. (In fact, you should never rely on "sig figs" at all!)

Calculations

In general, calculations only need to be included in a laboratory notebook when they lead directly to another data point or another experiment. When this is the case, the calculation should be accompanied by a short statement of the conclusion drawn from it and the action taken. Calculations in support of the after-the-fact analysis of an experiment or set of experiments may be recorded in a laboratory notebook if you wish, or they may appear elsewhere.

Regardless of where calculations appear, you must:

- Use enough digits to avoid unintended loss of significance. (Don't introduce round-off errors in the middle of a calculation.) This usually means use at least two more "guard" digits beyond the number of "significant figures" you expect your answer to have.
- You may round for convenience only to the extent that you do not lose significance.
- Always calculate and express uncertainty separately from the measurement. Never rely on "sig figs" to express uncertainty.
- Leave digits in the calculator between steps. (Don't round until the end.)
- When in doubt, keep plenty of "guard digits" (digits after the place where you think you will end up rounding).

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Integrity of Data

Your data are your data. In classroom settings, people often get the idea that the goal is to report an uncertainty that reflects the difference between the measured value and the “correct” value. That idea certainly doesn’t work in real life—if you knew the “correct” value you wouldn’t need to make measurements!

In all cases—in the classroom and in real life—you need to determine the uncertainty of your own measurement by scrutinizing your own measurement procedures and your own analysis. Then you judge how well they agree. For example, we would say that the quantities 10 ± 2 and 11 ± 2 agree reasonably well, because there is considerable overlap between their probability distributions. However, 10 ± 0.2 does not agree with 11 ± 0.2 , because there is no overlap.

If you get an impossible result or if your results disagree with well-established results, you should look for and comment on possible problems with your procedure and/or measurements that could have caused the differences you observed. You must *never* fudge your data to improve the agreement.

Your Laboratory Notebook is *Not* a Report

Many high school students are taught that a laboratory notebook should be a journal-style book in which they must write perfect after-the-fact reports, but they are not allowed to change anything if they make a mistake. This is not at all what laboratory notebooks were ever meant to be. A laboratory notebook does not need to be anything more than an official signed and dated record of your procedure (what you did) and your data (what happened) at the exact instant that you took it and wrote it down.

Of course, because it is your journal, your laboratory notebook *may* contain anything else that you think is relevant. You may choose to include an explanation of the motivations for one or more experiments, the reasons you chose the procedure that you used, alternative procedures or experiments you may have considered, ideas for future experiments, *etc.* Or you may choose to record these things separately and cross-reference them to specific pages in your lab notebook.

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