**Laboratory Notebook Norms**

The goal for a laboratory notebook is to provide a permanent record of what you did. The purpose of such a record includes allowing someone else to fully reproduce your experiment or establishing legal proof of a patentable discovery or idea. In a research setting, this notebook can have a legal status because it provides written proof of when an important discovery was made. In industry, you would be required to have a "witness" sign and date the pages where an important discovery was recorded.

These goals establish the requirements for a laboratory notebook. This record ***must be easily readable*** at some later time by you or anyone else. The content of the notebook must contain complete descriptions of the motivation and goals for an experiment; the methods used to achieve those goals, including materials, equipment, and technical approach; the results of the experiment; the analysis of those results; and the conclusions drawn from the experiments. The absence of any of these can make it impossible to understand what may be the source of results that are unexpected or in contradiction with other experiments. The highest quality notebook is one where another person could readily reproduce those results or find the source of a problem by simply following the notebook. Below this standard is a notebook that allows a reader to understand what the author has done but without sufficient detail for the reader to be confident of being able to repeat in detail the author's work. The minimum acceptable standard is that with the passage of time the author of the notes could still repeat what they have done by following their notes.

Keeping notes requires a level of judgment about what to include and how best to organize it. The safest thing is to include everything that is done, even when it seems unimportant at the time; in retrospect previously unconsidered factors may turn out to be important. However, the more information (especially of the sort that is not clearly recognized as crucial) there is, the more difficult it is to track down any given piece of information that one may wish to find later. To facilitate the function of a lab notebook as a useful record, it is essential that information be well differentiated. This can be accomplished by various means including headings, indentation, enclosure within boxes, different color ink, etc.

For this course you are required to keep an electronic lab notebook. Our Department provides this ELN system to all students registered for PHY 451 in Spring 2014 without charge. In return, you will fill up an survey to provide feedback to the Department. Note that this is the first time we implement such an ELN system. You should invest time to learn how to use such an ELN effectively.

If you cannot participate in using such an ELN, please contact me immediately. You may use soft-sided 9" x 12" 'Computation Notebook' not an 8" x 10" hardback book. You can purchase these notebooks for $7.90 from University Stores in the Angell Building at 166 Service Rd., Room 101 (517-355-1700). It is item number 14042680. You may also be able to buy these at the Biochemistry Research Store in Room 110 Biochemistry.

**Requirements for keeping a good notebook**

- The notebook must be easy for another person to read and understand both in terms of the handwriting and in terms of the organization.
- You must have a table of contents by which a reader can easily determine where to find important information about your experiments.
- At the beginning of a new experiment you must describe it, tell what you hope to accomplish and how you will be doing it.
- Each day's entry should begin with a date, time, a brief statement of what you plan to do and why. During the experiment, you may want to record other times because the phenomena you are observing might be time dependent. Also later on you might want to anticipate how long it takes for certain equipment to warm up, liquid helium to be transferred into a cryostat (and how long it will last), etc.
- Careful drawings of your experimental set up must be made. Of course, with the advent of digital cameras, it is acceptable to photograph your apparatus and paste an annotated picture of it into your

notebook when this makes the record clearer. However, a photograph is not necessarily preferable to a drawing. For example, it will probably be easier to draw some circuit diagrams by hand. You should record the ***manufacturer's name and model number of each crucial piece of equipment used in your experim*ents**.

- Estimates of systematic and random experimental errors should be recorded. "How accurate is my caliper and to what precision did I measure that distance?" "Does the instrument read zero when there is no signal present?" "Is the reading drifting with time?"
- Sometimes you will be taking data with a computer, and you certainly will be using a computer to create graphs. It is very important to ***record in your notebook the names of these data and graphing files*.** Likewise, if you write a program to analyze your results, you should record the file name. However, data that can reasonably tabulated should also be so tabulated in the lab notebook as computer files are highly impermanent.
- At the end of each session, make a summary of your accomplishments and unresolved problems, as well as your plans for the next laboratory period.
- Since you are expected to also be doing work outside of your normal lab sessions, it would be a very good idea to make entries in the notebook (with dates, times, etc.) that show the results of this outside-lab work. We will be looking for these entries as we evaluate your performance in this class.
- Writing results on pieces of paper and then copying them later into the notebook is strictly forbidden! If you make a mistake, just cross it out (but leave it legible, in case your "mistake" wasn't actually a mistake) and write down the correct input. The temporal order of the record can be crucial, so significant empty spaces should not be left or, if present, should be crossed out.

Keeping your lab book in a neat compact and orderly arrangement will enable you to reconstruct for any given day what you did. Using the experimental data and your lab book, you will prepare a lab report for experiment #1 and a final report (term paper) for experiment #2 or #3. We may collect your notebook at any time in order to evaluate how you are doing. You should be especially prepared for us to check your lab notebooks at the beginning of each new experimental cycle.

The following are some more guidelines to follow when performing laboratory work.

- Writing results down on pieces of paper and then copying them later into the notebook is not allowed. Don't ever erase, use whiteout, or tear out pages of a lab notebook. If you make mistake, just cross it out (but leave it legible, in case your "mistake" wasn't so) and write down the correct input. These may prove to be not so incorrect as initially thought and will very often be useful as a guide to how the experiment was done and provide clues on how to better execute the experiment next time.
- Create a descriptive table of contents and make an entry every time you add new material. Title the TOC with the following: Date – Contents – Page. Use descriptive headings that will be useful later on when reviewing your notebooks.
- **Number and date every page.** Each day's entry should begin with a date, time, and brief statement of what you plan to do. Preparatory questions and solutions should be written in your lab notebooks. Following the preparatory questions, state the essential physics of the experiment in your own words. List your experimental objectives and how they relate to the essential physics. After listing the objectives, identify the things you will have to do, the data you must obtain and identify the required calibrations.
- During the experiment, you may want to record other times because the phenomena you are observing might be time dependent.
- Careful drawings of your experimental set up must be done. Of course, with advent of digital cameras, it is acceptable to photograph your apparatus and paste an annotated picture of it into your

notebook. However, it will probably be easier to draw some diagrams describing optical paths by hand.

- Estimates of systematic and random experimental errors should be recorded. “How accurate is my caliper and to what precision did I measure that distance?” “Does the instrument read zero when there is no signal present?” “Is the reading drifting with time?”
- Sometimes you will be taking data with a computer, and you certainly will be using a computer to create graphs. It is very important to **record in your notebook the names of these data and graphing files.** Likewise, if you write a program to analyze your results, you should record the file name.
- At the end of each session, make a summary of your accomplishments and unresolved problems. This can be useful for you to **write a lab report outside of your normal lab sessions**.