

## Procedures for Experiments

Phy 344/462

**Introduction:**

Your work in this course needs to be recorded in a laboratory notebook. Such a book is used by all experimental scientists. It is where grand concepts and minute details of experiments are written down. You should think of your notebook as a guide for another scientist to understand how you performed your experiment and interpreted the results that you obtained, with sufficient detail so that he/she could repeat your measurements and obtain the same results. The following topics are common to most experiments and you should include them for each experiment you perform:

**A. *Experimental Design.*** You are not responsible for the basic experimental design and apparatus for most of the experiments you will perform; however, you are responsible for completely understanding this design and documenting your understanding.

1. Please include enough diagrams, notes and references to explain the apparatus and its use. Sketches of different aspects of your experiment with some well-chosen labels are extremely helpful.
2. Major components of the apparatus such as power supplies or measuring instruments should be clearly identified.
3. If calculations are required for the experiment these should be done here.
4. You may use Xerox copies of pages from books, etc. to illustrate the design. Use clear tape to attach these in your notebook.

**B. *Testing of Apparatus.*** It is possible to destroy many instruments by improper connections between components or improper settings of the apparatus. Carefully record the initial arrangements you have made before starting any experiments, explaining how you determined them. *Have a staff member sign off before you turn on the power of any equipment.*

1. You should include a log of the procedures you use to verify that the apparatus is functioning.
2. Include a log of any calibration measurements you performed.

3. You may wish to include notes about any problems you encounter or about proposed improvements to the apparatus.

**C. *Measurement Log.*** Having verified that the apparatus is functioning properly, you will normally perform a series of measurements. These should be carefully recorded.

1. Use tables to record your measurements whenever possible. Always record the actual values you measure, not calculations based upon them.
2. You should occasionally check that measurements you performed early can be produced later on, as the apparatus or specimen may change during the measurement. In addition, by repeating a measurement you will gain an indication of the errors involved.
3. Be careful to specify the uncertainty for any measurement you make.
4. It is often advisable to prepare rough graphs of the results of your measurements as you are taking them; measurements very often give unexpected or unreliable results which only become obvious when they are graphed. You may make such a plot either by hand using the grid in your notebook or by entering your data into the plotting program *Origin*, then printing out the graph and taping it into your notebook.
5. Include notes and diagrams to illustrate any unexpected occurrences or accidents during the measurement.

**D. *Analysis.*** When you think that a set of measurements is finished, you will normally “turn off” the apparatus and do further analysis of your results. This analysis may include “data reduction” (i.e. calculations based on the measurements), error estimates and comparison with theoretical predictions. In the analysis section of your write up you should include:

1. Calculational procedures: formulae, computer programs, etc.
2. Numerical results of calculations.
3. Calculation of uncertainties in final quantities.
4. Graphs of the calculations.
5. Discussion of the results.
6. Discussion of any possible sources of systematic error and methods to reduce them in a future experiment.

In preparing your notebook, please use the following procedures:

1. Entries in your notebook should be dated and in some cases the hour should be noted as well.
2. Do not erase early entries in a notebook, nor remove the pages. You can annotate your earlier entries to indicate later work that affects their interpretation.
3. Save the first few pages of the notebook for a *Table of Contents*. This serves two purposes: it encourages you to think about how the experiment is organized and it helps locate important entries.

### *References*

1. E. Bright Wilson, *An Introduction to Scientific Research*, (McGraw-Hill Book Co. 1952). This book, while hopelessly outdated regarding instruments, is among the wisest of handbooks on experimentation. It contains the important advice: “Many scientists owe their greatness not to their skill in solving problems but to their wisdom in choosing them.”
2. D. C. Baird, *Experimentation: An Introduction to Measurement Theory and Experimental Design, Second Edition*, (Prentice Hall, 1988). A well known guide.