# EXPERIMENT SUMMARY

1. Experiments are done to provide **critical tests of physical models**, to determine the **physical properties of a system**, or to **constrain fundamental constants**. An understanding of the underlying physical principles is needed before you can begin. Your logbook should contain sufficient background information to make clear the physics being addressed in the experiment.
2. The **design of the experiment** is based on the problem that is being addressed and it includes estimates of the **anticipated sources of error**. Your logbook should contain sufficient information to show how the planned experiment will work to answer the objectives.
3. The **equipment and apparatus are selected and tested** to ensure that they are appropriate for the task and that they are working properly. The logbook should contain detailed information on the tests performed.
4. **The data** are recorded directly into the logbook, or, if an automated acquisition system is being used, references to the data files are kept along with examples of typical data files (with explanations). **A preliminary analysis** should be done in the logbook ASAP, to make sure the experiment is working according to the design.
5. When you are satisfied that sufficient, good quality data have been acquired, the **detailed analysis** can be done, including a **rigorous analysis of the errors**.
6. Finally, you **publish the results.** In Phys 372, this means that you write a report in the form of a Physical Reviews Letter.

# WHAT TO DO IN THE LAB

**LAB NOTEBOOKS - What you write and when**

You must maintain a bound laboratory notebook in which you record all observations and data, and in which preliminary calculations are performed. The lab notebook is kept in the form of a logbook. Do not record data on loose pieces of paper. We expect your notebook to resemble one produced by of a professional scientist.

**WHAT THE NOTEBOOK IS FOR:**

The notebook should be structured to record the progress of the experiment. Thus, the data acquired, and the calculations made during the experiment are systematized by being written in the notebook, and are kept there for later use. A "typical" scenario might be a data-run with a machine operated by a group of 5 researchers working round-the-clock for two weeks. During that time, machine and experimental problems arise and are solved (or not solved), and experimental details are changed to answer new questions posed by the data obtained. At a later time (sometimes as much as 5 years later) the data from this run are combined with data from other runs, final calculations are made, and a paper is submitted for publication. Months later, the paper gets returned by the journal's referee with comments requesting revisions. The original data and calculations are then used as a basis for revisions. The revised paper then gets published. Finally, ten years later, there is a patent dispute based on findings from the experiment. In the court proceedings, the original lab notes are used as evidence.

**WHEN ENTRIES ARE MADE IN THE NOTEBOOK**:
Whenever you do any work on an experiment, you should be making entries in the notebook. Often, recollection of the exact sequence of happenings in the lab is helped by being able to tie the entry to a given day and time. Logbook entries thus start with a brief description of what the experiment is all about. The next entries should be jottings on your preliminary background reading and investigation. The book should then progress through records of your experimental set-up, should include data (which is both numbers and narrative) and calculations, and end in evaluations and conclusions. All these entries must be made simultaneously with the actions they describe. Thus, indications of apparatus idiosyncrasies must be written at the time the idiosyncrasies are observed, not two weeks later.

**WHAT SHOULD BE ENTERED IN YOUR LAB NOTEBOOK**:
- Dates (and times) liberally spread throughout the data/figures/narratives.
- Page numbers; all pages should be sequentially numbered. Never tear any pages from your logbook. Use of liquid paper or covering up of any information is PROHIBITED.
- Sketches of the apparatus and of important details of the apparatus. In most cases, schematic representations are preferable to pictorial detail. This is particularly relevant to circuits.
- Data: numbers, comments and descriptions, systematically entered (in tabular form where possible). All the data should be there, including the data that failed (with annotation of why it failed). Note that error estimates are an important part of your data.
- Preliminary calculations based on the data, preferably also in tabular form, and preferably as extended columns in the data table. You do not have to include detailed arithmetic, although algebraic equations, explaining how each calculated column in the table was found, are useful. Show at least one calculation in the full.
- Preliminary graphs based on the preliminary calculations and inserted with the data. These graphs should be well labeled and dated, and should be liberally annotated with remarks about features of the graph as related to oddities in the data-gathering process.

Preliminary calculations and graphs should always be made while the data are being accumulated. Most experimentalists do a preliminary experiment and analysis to see if it all makes sense and to determine the best way to do the experiment. Then they do what they hope is the real experiment.

- Data sheets produced by your equipment (chart recorder sheets, computer output, etc.). Such sheets should be dated and cross-referenced to the writing in your book and annotated re notable occurrences. They should be firmly attached to the book.
- Final, more elaborate, calculations and graphs.
- Final comments, conclusions, thoughts about the experiment.

**IN GENERAL**:
The logbook should contain a complete record of the experiment. Each entry must be long enough to allow you to fully reconstruct the experiment from the written record. Organization is essential; it is important for you to plan the work before you start in order to optimize the time is spent working in the lab.