Physics 310
Intermediate Experimental Physics
Room 430, Clark Hall
Spring 2006

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Introduction

Welcome to Physics 310, Intermediate Experimental Physics. In this course, you will carry out complete experiments, analyze the data, and write reports on your work that are similar to journal articles.

Schedule

Lab: *Tuesday & Thursday, 1:25-4:30*
In addition, starting about 2 weeks into the course the lab will be open to you from 8:30 to 4:30, Monday through Friday.

Lectures: *Tuesdays 1:25 – 2:30, Clark 309*
Feb 7 Experimental uncertainties
Feb 14 Report writing

Student Presentations: *Tuesdays 1:25-2:30, Clark 309*
Feb 28
Mar 14
Mar 28
Apr 11

Experiments

There are nine different experiments, of which you will do three or four. They are:

- Balmer Series for Hydrogen and Deuterium (2 *weeks*)
- Franck-Hertz Experiment (2 *weeks*)
- E/m for the Electron (2 *weeks*)
- Beta-Decay and Isotope Lifetime (2 *weeks*)
- Gamma-Ray Absorption (3 *weeks*)
- Geometrical Optics (3 *weeks*)
- X-ray Absorption and Scattering (3 *weeks*)

- Transient Response and Electrical Resonance (4 *weeks*)
- Millikan Oil-drop Experiment (4 *weeks*)

In addition, a few experiments in the Advanced Laboratory may also be available to us as mentioned above. These include:

- The Stern-Gerlach Experiment (E-4) (2 *weeks*)
- Gamma-Ray Spectroscopy and Absorption (N-0 and N-1) (2 *weeks*)
- The Michelson Interferometer (O-2) (2 *weeks*)

From this set of experiments, you are expected to do 10 *weeks* worth of work. Hopefully you will be able to do the experiments that you are most interested in. In order to make the apparatus available to as many students as possible, you will need to complete your lab work on each experiment within the specified time.

In general, you will be working on your own, without a lab partner. There are handouts for each experiment, indicating objectives and providing some instructions, but the approach to the completion of the experiment and the depth of investigation and analysis are, to a large extent up to you.

Presentations

You will each give a 15-minute presentation to the class on one of your experiments. Your talk should cover the motivation for the experiment, your method, results and conclusions. It need not cover every detail of the experiment, but it does need to cover enough so that your listeners come away with an understanding of its key aspects. Indeed, you will probably find that to stay within the time limit, and yet communicate effectively, you will have to make choices about what to emphasize. Your talk should use slides. Both an overhead projector and an LCD projector (for Powerpoint-style slides on a computer) will be available.

Grading

Lab reports – 90%
Presentation – 10%

Lab reports will be graded on a 1 to 10 scale, and your overall lab report grade will be based on the average of those numbers, weighted according to the lab's length. If you do more than 10 *week*s' work, the best 10 *weeks* will count with some consideration for the extra work. Completing the work specified in the handout for a lab, and writing a coherent, accurate, and complete report, including error analysis, will generally result in a grade of 7 (approximately equivalent to a B). Higher grades will require more work, such as some experimental approach not included in the handout, especially careful work, or an exceptionally good error calculation. Sloppy or missing work and mistakes will obviously lower the grade. I will be happy to discuss your data and the analysis with you before you turn in your report.

Please note that I cannot grade all the lab reports at the end of the semester. To avoid this, it would be appropriate to follow the rule that for an *n-week* lab, the lab report is due at the $(n+1)^{th}$ week after you start the lab. In general, late reports will not be accepted. Exceptions to this need to be discussed individually.

Presentations will be graded on their effectiveness in communicating the motivation, method and findings of the experiment within the allotted time.

Advice

What should you do to get the most out of this course? In the first place, you should come to the scheduled laboratory sessions. Much of the time during these sessions will be spent working on the equipment and taking data, but, in addition, some of the time should be spent analyzing the raw data on the spot. This is unfortunately all to often disregarded and often you will find that there was some detail that you omitted or that there were a couple of wrong readings that lead you down an incorrect path.

You should plan to do most of your reading, some of your planning, and a significant portion of your detailed analysis of the results outside of lab hours. If you want to do a longer series of measurements on some of the experiments, the laboratory is open from 8:30 am to 4:30 pm Monday through Friday.

Analysis of Uncertainties

Very likely this is the first physics lab where you are expected to understand your uncertainties quantitatively. The point of the experiments is not to obtain the *right* result, but to understand how much confidence you can have in the result you obtain from your measurements. Of course, you would like to keep your uncertainties as small as possible. You will also want to compare your result to generally accepted, or to theoretical, values. For example, if the analysis of your data yields $(2.0 \pm 0.2) \times 10^8$ m/s for the speed of light, you should look for a systematic error in your equipment or analysis, or else seriously doubt your method of error analysis. I hope that the handout *Basic Formulae for Calculating Errors* will give you a useful start. The handouts *The Estimation of Uncertainties in Experimental Results* and *The X^2 Test* are meant as an introduction to error analysis.

Notebooks and Lab Reports

It is best to keep a notebook in which to record all your data. A quadrille-ruled spiral-bound book is just fine. Loose sheets are known to get lost and should only be used for a first few trials or quick calculations. Write notes about your intentions and observations as you go, so that your numbers make sense to you later. Rarely does one write too much. Include the date when you took data.

The completed lab report should contain:

- An introduction, which includes a brief description (with references) of the physics topics to be studied.

- A description of the equipment, including diagrams as needed.

- The raw data, well-organized and labeled.

- Graphs of the data, as needed, including error bars when possible.

- Sample calculations to show how you analyzed your data (the formulae that you use may already have appeared in the introduction)

- Error analysis, again with sample calculations if applicable.

- A well-marked display of your final results, and their uncertainties.

- A discussion of your final results. In this section, you will presumably refer back to your introduction, and draw some conclusion about whether you were able to meet the goal of your experiment. What physics results did you get? Do your results agree with the accepted values, or are there discrepancies? Remember that *agreement* and *discrepancies* only make sense if you can discuss them in terms of your errors.

Typical lab reports are 5-10 pages in length, not counting tables, graphs and figures. If you find that your report is outside this range, come see me. Your report need not be typed. It depends on you, and also on the experiment. If you type your report and/or plot your graphs using your computer, you need not copy your raw data or calculations from your notebook, as long as they are legible. Designate clearly in the report on which pages they can be found, and turn in the book along with the report.

Getting Help

I will be in laboratory during lab hours to help you while you are working on the labs and their analysis, and also with filling in physics background that you may not have had from previous courses. For help outside of the lab hours, feel free to come to my office, 116 Newman Laboratory, by appointment through email to insure that I am there. I hope you will enjoy this course!