Advanced Lab I & II May 16, 2012
PHYSICS 4321 & 4322
Summer 2012

Instructor: Prof. First (Office N018, Lab S03/S06 & sometimes W103)
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Lab Hours: 2:05pm-5:25pm Tuesday and Thursday, through July 26.

Prerequisites: A prerequisite of a quantum theory course is recommended. In addition to providing laboratory experience, some experiments are intended to provide an introduction to topics that may receive little coverage in other courses.

Course Requirements: This is largely a self-study course. Students are expected to do background reading and literature research as appropriate for the lab reports. Course grades will be based on fulfillment of the following requirements:

1. (95%) Completion of four (4) experiments and lab reports.

   (a) The lab report for a completed experiment *must* be submitted before beginning the next scheduled experiment. The last lab report is due before the end of the final week of classes. *REPORT SUBMISSION:* Turn in one hardcopy and email one PDF to your Instructor. If color is essential, print the hardcopy in color.
   (b) During a 10-week Summer session, the lab cycle will be about 2.5 weeks per lab (schedule to be arranged by the second course meeting). Most labs will require 2 periods of data acquisition. It pays to read through the lab instructions prior to class!
   (c) Each student must turn in their own *original* lab report! Although you work in pairs, your laboratory reports are written individually. The protocol is to take data together, but perform the data analysis and write-up separately. This doesn't preclude discussing data analysis with your partner, but lab reports that are close duplicates will not be graded.
   (d) All lab partners must be present during the experiments. If you miss a lab for some reason, you must make up the laboratory work regardless of the work your partner has already finished. Failure to be present for all of the labs for a given experiment will force an **F** for that experiment regardless of the quality of your laboratory work.
   (e) All of the experiments are operational. However, it's your job to learn how to control the equipment and perform the data acquisition effectively. The purpose of this course is for you to learn how to solve experimental problems in an independent manner. The instructor(s) can answer general questions and provide some assistance with the apparatus, but the responsibility for data acquisition and analysis lies with you. *Report any equipment malfunctions immediately!*

2. (5%) Laboratory notebook.
   Data and notes must be recorded in a laboratory notebook devoted to this class. ***DO NOT*** *use loose paper to record experimental data!* Some data will be acquired via computer, but notes (including computer file names) and equipment settings should still be recorded in your notebook. Data recorded by one partner as the other adjusts settings should be copied into both partners' notebooks (for extensive tables, a photo-copy is acceptable, but it should be pasted, taped, or stapled onto the notebook page). Laboratory notebooks will be spot-checked and/or collected during the term.

Grading: Your grade is determined by the reports and by your laboratory notebook.

(a) Lab report scores will be assigned follows:

Clarity of presentation	3/3 pts
Quality of data	3/3 pts
Analysis of results, including errors	4/4 pts
Extra points (1 for working alone, 0.5 for working in pairs, 0.25 in threes)	1 pt
TOTAL	11/10

A rough grade breakdown is A = 9-10, B = 8-9, C = 7-8, D = 6-7, F = 0-6.

(b) Lab notebooks will be graded 0-5 based on their (legible) content, which should include, for example:

- The date and periodic time entries.
- Sketches of experimental arrangements and electrical connections.
- Observational notes or sketches on the experiment and equipment.
- Data in tabular form.
- Uncertainty estimates

Your notebook needn't be pretty, but it has to be functional. Someone besides yourself should be able to understand what is written. Take a little time to think about how the data will be recorded, make certain that numbers are legible, and *record uncertainty estimates.*

Resources

- All resources can be accessed through the course T-square site.
- Manuals for individual laboratories are also online at advancedlab.physics.gatech.edu.
- Other available materials cover:
  - Error analysis
  - LaTeX typesetting and sample report template (MIT)
  - Lab advice
  - Miscellaneous monographs (plagiarism, writing research papers, more?)

LAB REPORTS

Report Format: A rigid format for the reports is not prescribed but they must be typeset (LaTeX or a word processor) and should be submitted electronically as a PDF file. The report style should be similar to an article in Physical Review. See the American Institute of Physics "Style Manual" for ideas, and read a few Physical Review (Letters,A,B,C,D,E,X) articles.

Report elements:

1. **Introduction:** Here you should explain what you intend to do and how it fits into the context of physics in general. A historical context is often a good way to begin the introduction, but don't make it excessively long.

2. **Apparatus and Experimental Procedure:** A clear schematic drawing of the experimental apparatus should be given that labels all critical parts. Photographs generally are not as effective as a drawing for this purpose.

3. **Figures, Tables, and Equations:** All figures, tables, and equations should be numbered in ascending order so that they can be referred to in the text. Figures and tables should have captions with a brief description of what they are about **(label all figure axes)**. Do not put all the figures at the end of the report. They should be placed in the body of the report as they are introduced. Equations should be numbered and used to explain how the data was analyzed or why the functional dependence in a figure has a particular form. Color can be useful in figures, but use it carefully; all essential information should be easily discernible in a black & white printout.

4. **Theoretical Considerations:** To whatever extent seems feasible, the experimental work should be connected with theory. You should demonstrate evidence of outside study that enables you to present at least a descriptive account of the relevant physics. It is important to relate this theoretical material to your laboratory observations.

5. **Uncertainties:** An analysis and discussion of the measurement uncertainties and systematic errors must be given in the report. *No measured data or any calculated value from the data should be given in the report without an error bar on it!*

6. **Conclusion:** Your conclusion should clarify all of the experiments you performed. You should discuss whether or not your measurements agree with accepted values. If they differ, you should explain possible reasons (with supporting calculations) why they are different from the expected value. It should also explain the major source of error in your measurements and how you would change the experiment to improve your results.

7. **References:** Literature references (including the original papers!) should be cited in a consistent style, preferably ordered numerically. Information that you receive from another person (not including the instructors), also should be cited.

The report should be written as if the person reading it has a general knowledge of physics but has never seen the experiment. **Here are common issues that come up in lab reports:**

1. Succinctness. Don't use more words than necessary to communicate what you have learned. Clarity of presentation, grammar and readability, are very important.
2. Only include as many digits in a measured quantity as are significant. A statement such as "We measured the value to be 3.1538 +/- 0.2 Joules" is overly precise—can you understand why?
3. Historical introduction should be limited to what is needed for understanding the data.
4. The report should not be a lab manual. Include enough information for a general reader to understand how the experiment was performed, but not step-by-step instructions. The discussion of questions that are raised in the lab manual should be integrated into the report, i.e., write the report for a general reader who doesn't know (or care) about the lab manual that guided you.
5. Plan enough time to write the report, then reread and edit it after a day's break. It is surprising how much better your grade will be if you do this.
6. Put your most important data in the front of the report, with auxiliary data in an appendix IF it is necessary. For instance, enormous printouts of the raw computer-acquired data are not necessary; the graphed data is enough.

Available Labs:

Frank-Hertz Experiment

Nuclear Magnetic Resonance

Supplement (U. Washington)

Hall Effect

Deterministic Chaos

Photoelectric Effect

Cavendish Experiment

Rutherford Scattering

Modern Interferometry

Wave-Particle Duality

Muon Physics

Zeeman Effect

Two-Slit Interference

~~**Saturation Spectroscopy of Rubidium**~~