Physics 128B: Senior Lab
Spring 2012

Class Information

Labs: 1:00 – 6:00 PM M/W or T/R Broida 3223

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Course Web Page: http://web.physics.ucsb.edu/~phys128/

Course Requirements

- **Do four experiments from the lab manual that you did not do last quarter.** Note: Mass of the electron is new this quarter.
  You will choose from the following experiments: mass of the electron, Johnson noise, laser properties, vacuum techniques, interferometry, holography, muon lifetime, H-D Isotope shift, Mossbauer Effect, PNMR, gamma ray spectrometry. These are described on the course website.
- **Keep a good logbook record of each experiment.**
  You will need two logbooks; the TAs will grade one while you are using the other. You need to obtain high quality logbooks that have a grid, i.e., graph paper, on each page. They can be hardbound or spiral. (I prefer spiral so it will lay flat on a table).
- **Write a 1-2 page summary of each experiment**.
  Note: this is new this quarter and will be turned in with your lab book! It is a short (1-2 page) synopsis of the experiment with an abstract, an introduction, experimental method, discussion of results with ~ 2 relevant figures, and conclusions. The idea here is that you learn how to selectively and concisely present relevant data and present a coherent, conclusive result. A sample is shown here.
- **Prepare a 5-minute, 2- or 3-slide talk about every lab you are about to do.**
  You (and your lab partners) must *hand in* these transparencies on Day 1 of the lab. On Day 1 and Day 2 of each lab-block, groups will be randomly chosen to actually deliver their pre-prepared talks. (In other words, you must show up on Day 1 having read (and thought about) the lab already. You may not be permitted to start the lab until you've shown me that preparation.)

- Learn Mathematica or another reasonably-professional data analysis system (Igor Pro – also on the lab computers).

Course Grading

- **Lab Writeups** (logbook 60% + summary 25% = 85% of final grade)
  Due weekly at **1PM** on Mon (for M/W section) or Tues (for T/R section) in 3223 Broida or directly to your TA. Grading policy is detailed here.
- **Oral Presentations** (15% of final grade)
- **Late Policy:** you are allowed **one late assignment** (maximum of 72 hours late). Any other late assignments will not be accepted.

Textbook and Material

The textbook for this class is *An Introduction to Error Analysis*, 2nd edition, by John R. Taylor. It is not required, but heavily recommended. It is in the bookstore and there are a couple of copies in the lab available for checkout. Additionally, they are on reserve at the library.

Other useful texts:

Data Reduction and Error Analysis, 3rd edition, by Bevington and Robinson.

Tentative Schedule

Apr 2(3)	Lecture and Organization
Apr 4(5) - 16(17)	Lab #1
Apr 18(19) - Apr 30(May 1)	Lab #2
May 2(3) – May 14(15)	Lab #3
May 16(17) – May 28(29)	Lab #4

Safety

There are important safety issues in any lab work, of which you must be aware. Some examples of safety hazards are intense light sources (lasers and gas discharge tubes), electrical hazards (high voltage or current), radiation sources (radioactive substances or X-ray machines), extreme temperatures. **I require that you start each experiment by doing an assessment of the safety issues.** You will need to take steps to carry out your experiments safely; this is part of acting like a professional experimentalist. For example:

- Look for safety-related information in the lab manual.
- Look for safety-related information in the equipment manuals.
- Ask an instructor about anything that concerns you.
- Include safety in the planning discussions with your lab partner.
- Communicate clearly and unambiguously with your lab partner while working.

Important safety rules that everyone must follow are:

- You must never work on equipment alone. There must always be at least two people in the room.
- Never leave activated equipment unattended without approval from an instructor.
- If any accident occurs, you must immediately report it to an instructor.

How to do well

This course is quite different from most of your past classes. Skills that you have honed in past coursework may not apply, and you will need a completely different skill set. For some of you, these may come as naturally as algebra. For others, they might take a while to develop. Learning those skills is a primary goal of this class. Here is my advice on how to approach things.

1. Accept that you are confused. Identify what you don't understand. This part never changes. If you know what you are doing, it is just an exercise, not research.
2. Formulate a set of specific questions. Pick some questions for which you think you know the answer, and confirm that. Pick some questions for which you can find an answer.
3. Plan a method for finding an answer to at least one of the questions.
4. Carry out your plan.
5. Go back to 1.

This approach works to attack problems of any scale. You can use it to understand a completely new physical phenomenon or to debug why your car won't start. Note that this is just a rephrasing of the scientific method. It works for things that are not always recognized as science, such as figuring out the behavior of financial markets or people--including yourself.

You will answer many of the questions experimentally, i.e., you will *measure* the answer. But, not all methods will be experimental. You will need to do substantial reading on your own to understand the theoretical issues underlying your experiments and how your equipment works. We have equipment manuals and a small library of books that you may check out; they must be returned by your next lab period. You should do such reading before you begin your labs. From it, you should develop a plan of action *before* you begin. Careful preparation is important because you won't have much time to work with the equipment. (This is true in most experimental work, e.g., when using shared equipment like a telescope.)

An important part of being prepared is understanding how your equipment works. Before using it, you should plan to fiddle around to learn about it. I encourage fiddling, but be careful not to break things. The best way to avoid that is to read the manuals beforehand and plan your fiddling. If the equipment is not working, or if

you break it, notify an instructor promptly. You will not get in trouble for breaking something, but you will be in trouble if you don't tell us about it.

Since time with the equipment is limited, you should carefully document everything that you do. You might not expect something to depend on the temperature or the time of day, but you should still record both. It could be helpful after you have collected all your data. For example, you might find that one particular set of data is completely inconsistent with the rest. By knowing when that data was recorded you can correlate it with other effects; perhaps someone powered on some other equipment that caused interference.

It is also useful to analyse the data as you take it. This can help you quickly identify problems. For example, if you are measuring voltage vs current, you should make a table in your logbook where each row is one measurement and has columns for: the time of the measurement, the voltage, the current, and any relevant comments. Then, as you are filling in the table you should also plot the data, e.g., on the opposite page of your logbook. Your plot might reveal a trend that can inform your subsequent work, such as helping you decide to use larger or smaller voltage steps to go faster or more carefully.

It will help your experiments succeed if you prepare well, clearly write down your plan, and fully document your work as you go. This is also what we will look for while grading your logbooks.