EXPERIMENTAL METHODS IN PHYSICS -- PH316
PORTLAND STATE UNIVERSITY
DEPARTMENT OF PHYSICS
SPRING TERM 2000

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Office Hours: Monday 11-12:30 and by appointment
Text: "Data reduction and error analysis for the physical sciences", by P.R. Bevington and D. K Robinson, McGraw-Hill, second edition, 1992

Course Aims, randomly....

- To teach through example to do error analysis.
- To advance the development and organization of thinking about physical systems.
- To show through interaction with new (or somewhat old) instrumental techniques the wonders of physics.
- To instill attitudes of independence, personal communication, and organization, all of which are essential for mastery of complex systems.
- To understand physical systems at a level often encountered only in a research environment, and to deepen that understanding.
- To understand why hard work and even properly functioning and powerful software and hardware do not guarantee meaningful results. In an experimental science, there are limits to accuracy and applicability.
- To instill in students the importance of keeping proper lab books.

Objective: Develop comfort level in performing a substantial experiment and to generate a suitable report to communicate the results.

Downloads: program to run and programs to use for analysis

Photoelectric experiment	photo.exe (19k)
Fortran programs	Fortran.zip (27k)
Pascal programs	Pascal.zip (147k)

Tentative Experiments

1. **Photoelectric effect**

This is a computer-simulated experiment with the objective to apply data reduction techniques to noisy photocurrent data and to extract from the data the value of Planck's constant and the work function of the sample.

2. Chaotic pendulum

Observe the behavior of a driven, damped pendulum and try to get a sense of the variety of phase space trajectories that can occur. Several lectures, related to chaos, will be presented at Lewis and Clark, April 7 and 8. Information is posted.

3. Measurement of the energy band gap of a semiconductor

In this experiment, we will determine the band gap between the valence and the conduction bands of a semiconductor material by measuring the current-voltage characteristics of a p-n junction at various temperatures.

4. Scanning tunneling microscopy

Observe if all goes well, individual atoms.

5. X-rays

See an X-ray machine and analyze the data.

6. Low temperature physics

Perform certain classic low temperature experiments. Transfer liquid nitrogen and liquid helium.
7. Material science related experiments

Assignments
1. Laboratory reports
Two laboratory reports are required. These reports will have to form suitable for submission to a physics journal, such as the American Journal of Physics (some of the editors are kind of dense, ... so maybe pick another) or the European Journal of Physics (note that the referee might be somewhat extremely dense). Include appropriate measures of your uncertainty.
Report 1. Photoelectric effect. This report is due April 27.
Report 2. Measurement of the bandgap of a semiconductor. This report is due no later than June 2.
2. Notebook/journal
Your labbook is due Thursday June 8 at 1:00 pm in Room 246 SB2. Make sure that everything you wanted to accomplish is done at that time.
3. Class participation
Your participation in the class is essential for a positive experience of everybody. This entails that you arrive on time, participate fully in the in-class exercises, and help your colleagues if you can.
4. Error analysis
Error analysis is expected for every experiment in your lab book, with the exception of the two experiments written up in the reports for which a suitable form would be to list the uncertainties that were obtained. Also, several problems are assigned out of the textbook.
5. Microthemes
Microtheme 1 Photoelectric effect. This is due April 6.
Microtheme 2 High school. Due May 25.
Microtheme 3 Singlehoff. Due June 1.

Grading
If you meet all deadlines, assignments, and you do a reasonable job on your notebook: A; if you miss deadlines and do reasonable job on your notebook: B; if you miss deadlines, you participate, but you do a poor job on your notebook: C; else lower. Plus and minus are given for in-between performances.

Notebook/journal/labbook
You should treat the lab notebook as a tool for individual learning. Fill it often, don't leave home without it, and use it!
What kind of entries can I put in my journal?
Remember to date all entries. The following kinds of entries you can use.
Questions:
What puzzles you?
Analyze your methods:
Can you discuss *how* you went about doing what you did? That is, *how* did you solve your problem? How did you figure out that idea was new to you? If you were stuck on something, *why were you stuck*? Is there something you learned about why you are stuck? What additional information do you need to know about it. How can find out? When should the methods you used not be used? (Knowing the limitations of methods is just as important as learning the methods.)
Clarifying concepts:
Have you just learned something better that you need to write down? Would making a table help? Or a drawing? In your own words, what does some law or new result really say to you? What does a law or result not say? When should it not be used?
Organizing your thoughts with lists or outlines:
Is it helpful for you to list or outline several topics?
Real life applications and relationships:
Did you just see some new relationships or connections with another field? Is there something clearer about how some law or result related to another field that seemed unrelated before?
Dialogue with yourself:
Can you answer a question that you previously wrote down? Do you understand something better that you discussed two weeks ago? Go ahead, answer to your earlier questions or comments. When doing this, it usually works best to refer to your earlier entry by that date. This is one of the most useful functions of keeping lab book. This is one way for a question or idea to be answered or developed over a long period of time until it is understood better.
Special interests:
Is there a special topic related to the course that interests you? Would you like to find out more about it?
Miscellaneous:

Anything else that springs to mind.
Additional tips:
Make the labbook useful to you. Jot things down. You do not have to write in complete sentences, whatever you write should be comprehensible, however. Make sketches, drawings, and tables of data. List ideas to remember.

Error analysis
For the necessary error analysis, a good reference is "Data reduction and error analysis for the physical sciences", by P.R. Bevington and D. K Robinson, McGraw-Hill, second edition, 1992. See review in Am. J. Phys. 61, 1993, 766. The software is on the website: www.physics.pdx.edu/~bodegom/ph316/. Fortran and Pascal. The following problems out of the book are assigned:

	Problems	Due date
Chapter 1:	1,2,4,6	April 6
Chapter 2:	3,7,15	April 6
Chapter 3:	2,5,6,9	April 13
Chapter 4:	1,8,10	April 13
Chapter 5:		
Chapter 6:	4,5	April 13

Microtheme 1: The photoelectric effect (due April 6)
Suppose you are Dr. Science, the question-and-answer person for a popular magazine called *Golf Today*. Readers of your magazine are invited to send letters to Dr. Science, who answers them in "Dear Abby" style in a special section of the magazine entitled "Win that Bet". One day you receive the following letter:

Dear Dr. Science:

My friends and I were playing golf the other day in St. Andrews and Sara told us that she heard from a reliable source that Einstein got his Nobel Prize in physics in 1921 for the photoelectric effect. Obviously, this is wrong: Albert is best known for the equation $E=mc^2$. Sara said no way: her source is an extremely reliable science nerd who she pays to take notes in all her classes (Sara has to exercise on the greens, of course). So she bet a sixpack of Guinness Stout. With a bet this important we absolutely need to know who is right. We do not understand why the photoelectric effect, if it even exists, is so important. Please, explain to Sara why she is wrong in terms we can understand (no complicated physics terms).

Sincerely,

Putting Away

Can you help Putting understand the photoelectric effect and why it is so important? Your task is to write an answer to Putting. Because space is at a premium, your explanation can only be one typed page long. If you want to include diagrams, include them on a separate sheet.

Dr. Bodegom's personal page
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