200702

PORTLAND STATE UNIVERSITY
DEPARTMENT OF PHYSICS
PH 316 METHODS OF EXPERIMENTAL PHYSICS
SPRING TERM 2007

Professor:	Erik Sánchez (503) 725-3819 esanchez@pdx.edu Room 422, Science Building 2
Office Hours:	Tuesday 1- 1:50 and by appointment (Room 201 normally)
Recommended Text (not required):	"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 basic 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 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.

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.
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 individual atoms and structures on the molecular level.
5. **Optical Coherence Tomography**
   Learn about interferometry
6. **SQUID**
   Perform certain classic low temperature experiments. Transfer liquid nitrogen.
7. **Vacuum Science**
   How to make thin films and the technology involved in creating a vacuum and use a spectrophotometer
8. **Sonoluminescence**
   Generate light from water.
9. **Peltier cooler**
   Calculate efficiencies.
10. **Quantum Conductance**
    Show quantized levels of conductance with a simple experiment.
11. **Microcontroller Experience**
    Learn about the basic stamp and other popular microcontrollers.

Assignments

1. **Laboratory reports**
   Two laboratory reports are required. These reports will have to form suitable for submission to a physics journal, use the AIP submission standard. Use the format exactly. Include appropriate measures of your uncertainty.

Report 1. Photoelectric effect report. This report is due May 8th.
Report 2. Vacuum Science report. This report is due no later than June 8th.

2. **Notebook/journal**
   Your lab book is due Friday June 8th at 5:00 pm in Room 128 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. Do not "trade off" on duties without learning the entire experiment.
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.
5. **Personal Experiment**
   You create a unique creative experiment with the equipment available to you (or you own). You must tell me what you plan to do two weeks after class starts. No explosives or overly dangerous experiments. Write up in a ~5 page report, free style format but accurate.
   Suggestions:
   -Tesla Coil (nothing over 1 MV, Ball Lightning, Electronic Experiment related device, magnet based experiment, etc...

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/lab book

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 lab book 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.

NOTE:

On Wed. April 11th from 9-1:00 pm a free vacuum science workshop will be offered by Varian (Room 201, SB1), it will help with your understanding in the vacuum related experiments. RSVP me.