Phys 312 - Experimental Physics
Spring 2010 - Princeton University

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Lectures:	Tuesday 12:30-1:20 , Room Jadwin 111
Labs:	Afternoons by arrangement with TAs
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In this class you will learn a variety of experimental techniques and perform measurements illustrating concepts discussed in advanced physics classes. Each week we will have a lecture discussing general experimental and data analysis techniques, but the main focus will be on lab work, it will give you a taste of experimental physics research. Unlike freshman labs, here your goal is not to simply follow a procedure, but to interact with the apparatus as an experimental physicist. That means you should explore how it behaves under different conditions, realize if something is not working as it should, and adjust your procedure to get the most out of the experiment. It's a different challenge than say a quantum mechanics class, but still quite a challenge. A large part of learning will take place in the labs in interactions with your instructors. You should not be shy in seeking their help.

You will need to complete 5 labs working in groups of 2 or 3, each lab taking approximately two weeks. A sign-up board will be available near room Jadwin 475 to schedule your labs. You can choose any combination of labs, except that everyone has to complete the electronics lab. The departmental machine shop class can be taken as one of the labs, if you have not taken it already. If you are taking half-and-half molecular biology/physics lab, you will need to complete 2 labs (1 electronics) in the second half of the semester, attend all classes and take the final exam. Lab manuals will be available online. You will get keys for the lab rooms and can work independently, but only after getting initial instructions from the TA responsible for that lab. For labs involving radioactive sources you will need to pass an online radiation safety course and will be issued a radiation-monitoring badge. You should expect to spend about 20-30 hours per lab.

A lab report will be due at the end of each two week period. The two week period begins on the date of your initial meeting with the person running the lab. Each student has to submit his or her own report. You can discuss data specifics but analysis and interpretation of data should be done independently.

It is important that you share your data (or lack thereof) with the TAs early, so they can identify common mistakes before you spend a lot of time analyzing the data. It is not worth struggling to analyzing poor data if you can retake it to resolve obvious problems. By the end of the first week you should meet the TA and discuss your progress and at the end of the two week period you may want to meet again to discuss any new things you have found, as it is often easier to show something than to write about it. Lab reports do not need to be very long, 5 to 7 pages, certainly no more than 10. They need to contain a brief summary of the physics and description of the apparatus, data plots, analysis, and a quantitative discussion of uncertainties and limitations of the experimental apparatus. To get a perfect score you need to show that you explored the experiment and optimized your data taking and analysis. This is not a writing class, you should spend more time in the lab than writing. Writing concise and informative technical reports is a challenge in itself and is not the main focus of this class. Therefore, the grade for each lab will be based 75% on the written lab report and 25% on your interaction with the TA.

In addition to lab reports we will have an oral exam around midterms and a written exam during the exam week. On the oral exam you will be asked questions about the labs you have performed. The written exam at the end of the term will cover the material in the lectures and the electronics lab. The grade will be determined by lab reports 65%, oral midterm 10% and written final 25%. All 5 reports are required to pass the class. Substantially late reports will be downgraded.

Approximate Lecture Schedule

Date	Lecture	Date	Lecture
February 2	Introduction and electronic circuits	March 23	Vacuum and cryogenics
February 9	Electronic circuits continued	March 30	Lasers and Optics
February 16	Data analysis techniques	April 6	Medical physics
February 23	Noise	April 13	Medical physics cont.
March 2	Radioactivity	Aril 20	Nanofabrication
March 9	High energy particle detection	April 27	Particle acceleration

Labs

Experiment	TA	Description
Electronics Lab (required)	Mike	Building a lock-in amplifier
Muon Decay	Andrzej	Measurement of the lifetime of cosmic muons stopped in a liquid scintillator
Mössbauer	Richard	Demonstration of the Mössbauer effect : recoilless emission and absorption of gamma rays
Holography	Richard	Recording of photographic laser holograms
β spectrum	Richard	Measurement of the energy spectrum of beta decay electrons
Positron decay	Richard	Measurement of the momentum distribution of gamma rays from positron decay
Photoelectric effect	Andrzej	Photoelectric effect: study of the photoemission of

		electrons
Coulomb force	Richard	Test of the $1/r^2$ nature of the Coulomb force
NMR	Andrzej	Nuclear Magnetic Resonance, Spin echo and measurements of transverse spin relaxation time
Optical pumping	Andrzej	Demonstration of optical pumping of Rb atoms and optical detection of magnetic resonance.
Chaotic pendulum	Mike	Study classical chaos in a rotary pendulum
Two-slit interference	Mike	Double-slit single photon interference measurements
He-Ne Laser	Mike	Explore He-Ne laser with external mirrors, Sagnac effect
Machine Shop	TBD	Three-week machine shop class, learn to use lathe, mill, drill press, etc.

Testbooks

There are no required textbooks for the class. A lot of the material discussed in lectures is available as handouts. However, the following textbooks will be helpful:

"The Art of Electronics" by Horowitz and Hill - standard reference for electronics
"Building Scientific Apparatus" by Moore, Davis, Coplan – Gives a lot of practical lab info
"Experiments in Modern Physics" by Melissinos and Napolitano –discusses some of the experiments that we do.
"Experimental Physics: Modern Methods" by Dunlap – Also covers some of our material

I suggest that you browse through these books and pick one to buy, especially if you can share several different books in your group. You also will need a reference for error analysis, such as Taylor or Bevington.