Experimental Physics Seminar
PHYS 210, Spring 2006
Department of Physics
Princeton University

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Class: Wednesday, 7:30 –10:20, Jadwin 475 and 469

Class structure

In the first half of the semester we will go over modern experimental physics techniques in major areas of physics: high energy and nuclear physics, condensed matter physics, atomic physics, astrophysics, and biophysics. The emphasis will be on actual hands-on experimental aspects. The underlying physics, some of which may be new to you, will be covered in a "hand-waving" fashion to give you a taste of things discussed in more advanced physics classes. You will be expected to read lecture notes available on the web before the class. We will typically have a 30-min lecture followed by "show-and-tell" of the experimental apparatus. The first three labs will be particularly hands-on and will focus on LabView, a program commonly used for computer control of experiments, and simple electronic circuits.

In the second half of the semester you will work on independent projects in groups of 2-4 people. A list of possible projects is given below. You are also welcome to propose your own project ideas. If you ever wanted to build a crazy contraption or demonstrate a counter-intuitive physical effect, now is your chance to do it with full support of Princeton Physics department! We are also looking for new ideas for Freshman lab experiments. If you didn't like one of the Freshman labs and can think of a good experiment along those lines, that would be a good project. We will provide machine shop support and cover reasonable expenditures. All projects have to be discussed with and approved by the instructor.

Class Evaluation

This is a pass/fail class, so evaluation will be fairly relaxed. You are expected to read lecture notes before coming to class, and keep a good lab book. In addition there will be the following oral and written reports:

March 15th (last class before spring break): Each group will make an informal (i.e. using the blackboard) proposal for their project.

March 29th (after spring break): Written project proposals due, one from each group, several pages long. The proposals should include some calculations indicating that the project is feasible, a reasonably specific experimental procedure, a list of needed components and a good bibliography.

In the second half of the semester instead of lectures we will have weekly group meetings, where a member of each group will give a brief report on the progress and describe any encountered problems and proposed solutions. The group members should rotate in giving the report.

May 3rd (last class of the semester): Each group will give a more formal presentation, 15-20 min long, using transparencies or a computer projector.

May 16th (end of reading period): Due date for a written report or a web page describing the project and results.

Syllabus

Date	Class	Lab
Feb 8	General introduction	LabView tutorial, data acquisition with a sound card
Feb 15	Lock-in Amplifier, Analog circuits.	Software lock-in amplifier, test and measurement equipment.
Feb 22	Basic Feedback	Temperature feedback circuit, data recording
Mar 1	Basic vacuum theory, elementary particle detectors, black body radiation	Solar cell fabrication, microwave black-body radiation, cosmic ray detection
Mar 8	Electric discharge theory, atomic levels, superconductivity	Electrical discharges, optical pumping, high temperature superconductors.
Mar 15	Optics, project discussion, presentation of project ideas	Observation of magnetic bacteria, project research
Break		
Mar 29	Project proposals due	
	Work on projects, weekly reports	
May 3	Final presentations	

Project ideas

1) Building a He-Ne laser and a laser ring gyroscope
2) Building a laser Doppler interferometer for sensitive measurements of fluid velocity.
3) Building an ultrasound Doppler radar.
4) Building a Laser projection TV
5) Building a laser-pumped atomic magnetic field sensor.
6) Fabricating a superconducting tunneling junction using a sputtering film deposition system.
7) Building a laser communication or eavesdropping system.

Examples of previous projects are available on the class website

Class Philosophy

The idea of this class is to introduce you to real-world laboratory environment, where there are no written procedures and one often runs into unforeseen problems. For example, none of the projects suggested above have been performed before. In doing original research one can only guess how hard any given problem is or if it has a solution at all. You should take a certain amount of risk in choosing your project. If an experiment is obvious and its results are predictable, it's usually not very interesting from the research standpoint. On the other hand, most experiments turn out to be more difficult than initially thought.

Reading material

There is no single book that covers the material. A good general reference is "Building Scientific Apparatus" by John H. Moore *et al*. Lecture notes will be available on the web ahead of each lecture. As part of the class you should learn how to do search for research articles using Web of Science and INSPEC (check links on home page).