ADVANCED LABORATORY

Physics 3340/4430/5430 Spring Semester, 2009

INSTRUCTORS

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E-MAIL LIST

Make sure you are receiving e-mails from our class list. You should have already received one.

WEB SITE

The web site for the class has general information as well as most of the lab writeups:

http://www.colorado.edu/physics/phys3340/phys3340_sp09/

ON BEING AN EXPERIMENTALIST

How much time does an experimentalist spend doing physics? Not much. Not if you think of "doing physics" as making the discovery, or even simply conceiving of an experiment. An experimental physicist's time is spent designing and constructing the experimental system and components. Most often the majority of the time is spent trying to understand why an experiment isn't working, and figuring out what modification to make. Experimental physicists wanting to detect gravity waves using a laser interferometer (the LIGO project) have been at it for two decades and they have *yet* to actually run an experiment where they expect to detect the very weak signals. The recent demonstration of Bose-Einstein Condensation here at the University of Colorado generated a lot of excitement in the scientific community. That was an experiment five or six years in the making. It could be said that is was five or six years in the trying, before everything, intellectual understanding and experimental techniques, converged to a successful outcome.

So what is an experimental physics training all about? A good experimental physicist has a deep knowledge of physical principles and a broad range of skills in addition to an expertise in some particular field of physics. The standard intellectual equipment list includes familiarity with several engineering disciplines such as electronics, mechanical design, strength of materials and vacuum technology and familiarity with instrumentation such as oscilloscopes, frequency counters, spectrum analyzers, voltmeters and the like. What distinguishes a good experimental physicist from a highly skilled technician? A good experimentalist *is* a highly skilled technician, yet the physicist has a very different set of goals: the outcome is verification of a theory, or a demonstration of some new principle, or the like, and the skills are used is to get from here to there in the shortest path. During the test of the first atom bomb, Enrico Fermi was said to be seen dropping bits of paper; by

observing their horizontal motion relative to their vertical fall, Fermi was able to estimate the energy of the blast. Nothing fancy, no sophisticated instrumentation, just simple physical principles gave him the rough answer he was looking for. Furthermore, a physicist's knowledge of physical principles allows he or she to be a generalist -- in this lab what you might learn about impedance matching in electronic circuits will enable you to generalize to impedance matching in mechanical systems to make a better machine.

The Advanced Laboratory course is designed to expose and equip you with some of the essential skills that an experimentalist should have. It is also designed to expose you to a variety of experimental physics topics, and to provide a sense of truly independent research.

ORGANIZATION

The three courses, Physics 3340/4430/5430 share facilities, instructors and meeting times. Physics 3340 is for undergraduates who have already taken Physics 3330, or an equivalent course in laboratory electronics. Physics 4430 is for undergraduates who have already completed Physics 3340. Physics 5430 is for graduate students, without prerequisites. The various course requirements are summarized in Table I and are described here and in following sections.

Table I. Summary of Laboratory Requirements	
What	***When***
Lab Attendance	*Regularly scheduled section*
Lecture attendance	*Tuesday 1:00-1:50 each week*
3" x 5" card progress report	*End of lab section each week*
Lab report	*After completion of an experiment*
Project report	*End of semester*
Oral report	*End of semester*

Each Laboratory section will have a primary instructor and possibly a second instructor, but the section instructor will not be familiar with all the possible experiments. Other instructors with expertise on particular experiments will be "on call" and you may need to find them to get help if your section instructor is not familiar with a particular experiment. The laboratories are available for working on experiments except between the hours of midnight and 6 a.m. Please note, though, that **attendance during your regular scheduled laboratory period is required unless you have made specific other arrangements with your primary lab instructor.**

The first week all students will do a projecting microscope experiment except those students in 5430 who prefer to do an electronics lab and students in 4430 who have previously done the microscope experiment. You are to submit a *proposal* for a sequence of additional experiments that you wish to complete. We do this so that we can schedule all of the requests to avoid conflicts with equipment usage. The proposal is further described below.

Scheduled lecture time is Tuesday from 1:00 to 1:50. The first lecture period will be an organizational meeting that will include a brief description of the available experiments and the facilities. Experimental writeups that note any special prerequisites, and that provide standard completion times (typically one to three weeks per experiment) are available on the web site. The completion times and prerequisites may differ for the three courses.

The remainder of the lecture periods will be used to cover a variety of topics including laboratory safety, and experimental methods, materials, and techniques. These periods may also be used for organizational purposes, reports, and meetings with students. **Attendance at the lectures is required**. Please note that various room changes, depending on the lecture, may be possible.

Each week you are required to complete a one-paragraph update on your progress with your current experiment on a 3x5 card. Your lab instructor will provide procedural details. At the completion of each experiment you are to hand in a lab report, which is described below in a separate section.

TEXT

The following texts are on reserve in the MathPhys Library in Duane Hall:

Building Scientific Apparatus: A practical guide to design and construction, John H. Moore, Christopher C. Davis and Michael A. Coplan, Perseus Books, Cambridge, MA, 3rd edition, 2003. This text is a valuable resource for experimentalists. Although there are no planned specific assignments from the book, its utility will vastly outlive the semester.

Experiments in Modern Physics, A. Melissinos and J. Napolitano, Academic Press, 2nd ed., 2003. (The 1st edition from 1966 is dated in some parts but still very useful.) Once again, there will be no assignments but this book will be useful this semester as well as in your future endeavors. The lab has a few copies of the first edition.

CONDUCT

Everything you do in the context of this lab, from writing lab reports, to taking care of your equipment, to giving presentations, is expected to be at a professional level. Please take responsibility for your equipment, take responsibility for your own safety and for the safety of others.

PROPOSALS

By 4:00 Friday of the first week you must submit a written proposal for a sequence of experiments. In completing your list, remember that only 5430 students can do the standard electronics lab experiments, and 4430 students who have taken 3340 cannot repeat experiments they have done previously. Physics 3330 electronics experiment will be done in one week. 5430 students are expected to do all "optional" parts to the 3330 labs and go beyond the material presented in the experiment instructions on some experiments. The instructors will approve proposals during the first two weeks, taking care to resolve equipment conflicts. The time spent on each experiment should not deviate from the standard without good cause. Students will normally work in pairs throughout the term. When turning in your proposals please indicate the name of your partner for each experiment and how flexible you are in terms of scheduling so we can best accommodate your choices with the available equipment. For example, if you can come to either afternoon session, or can come to either Thursday section, please indicate that on your proposal. We will shuffle students around between sections according to your wishes and equipment needs for the first week. After that you will have a primary section that you are expected to attend for the remainder of the term.

PROJECTS

The period starting the week after Spring Break to the end of the term will be set aside for projects. Projects should be selected in consultation with your instructor during the middle of the semester. They can be anything that offers you a chance to demonstrate independence and creativity. A wide variety of possible experiments or construction projects is acceptable as long as it is something that is not part of a standard experiment presented in one of the write-ups.

GRADING

There are 20 points possible for each week of lab. Thus if you do a 3 week experiment, it will be worth 60 points. The weekly reports are worth 20 points altogether. The project will be worth 60 points, the final oral report will be worth 20 points, and there will be a final 20 points awarded at the discretion of the instructor, taking into account any factors they feel are relevant such as how well you prepared ahead of time for the labs, how well you kept your notebook, if you did all the work while your partner napped, etc.. Attendance is required so if you miss a scheduled lab period without being excused by your instructor, you will automatically lose the 20 points possible for that week. If you convince your instructor that you had a sufficiently good reason for missing class (always much easier if you contact the instructor to discuss it before you miss the class) you will be able to make up the class. In addition to the assigned three-hour lab period, it is expected that additional time (usually at least an additional 3 hours /week) in the lab will be needed to complete the experiments. The instructions for each experiment and appropriate sections of the textbook as well as other reference material should be read before each scheduled lab period. There will be copies of instructions for each experiment available at each setup. You should pick up a copy of the instructions for an experiment you are to do a few weeks before you are to start it. If you cannot find a copy of the instructions, tell your instructor so they can have more copies made.

CU'S POLICY ON SEXUAL HARASSMENT

The University of Colorado Policy on Sexual Harassment applies to all students, staff and faculty. Sexual harassment is unwelcome sexual attention. It can involve intimidation, threats, coercion, or promises or create an environment that is hostile or offensive. Harassment may occur between members of the same or opposite gender and between any combination of members in the campus community: students, faculty, staff, and administrators. Harassment can occur anywhere on campus, including the classroom, the workplace, or a residence hall. Any student, staff or faculty member who believes s/he has been sexually harassed should contact the Office of Sexual Harassment (OSH) at 303-492-2127 or the Office of Judicial Affairs at 303-492-5550. Information about the OSH and the campus resources available to assist individuals who believe they have been sexually harassed can be obtained at: http://www.colorado.edu/sexualharassment/

LAB BOOK

You must have a lab book with numbered quadrille ruled pages. The 9" X 12" Ampad No. 22-156 Computation Book carried by the bookstore is suitable, but less expensive alternatives are also acceptable. You must keep a lab notebook where you record your data and all relevant information. This lab book must be indexed and used to record the original data, graphs, calculations and answers to all questions asked in the guide. Each lab book record must include the original data as recorded in the lab. While your entries must be legible, do not be overly concerned about neatness in the

original recording of data; it is more important to record the data directly in the lab book as you do the experiment. Your lab book should be sufficiently complete so that one could reconstruct the experiment at some later date from the information in the lab book without recourse to memory. The instructor may check the contents of your lab book from time to time, and will consider the adequacy of your entries in evaluating your work.

LABORATORY

The Laboratory is organized into three major geographic sections: Electronics, Optics, and Modern Physics. Storage of components and equipment is arranged accordingly. The laboratory equipment, electronic and optical components, and tools are organized and labeled. The optics rooms and the electronics lab are equipped with kits of components for the standard experiments. There is a single location in the lab for other components or equipment, except for standard tools, of which there are two sets, one in electronics and one in optics. Please tour the lab and familiarize yourself with the location of these items.

The lab is to be maintained in the condition in which it begins the semester. Of course, while equipment, tools and components can be collected and kept during the course of an experiment, they are to be returned to their homes when the experiment is finished.

EXPERIMENTS

Optics

Projection Microscope
Michelson Interferometer
Fraunhofer Diffraction
Fourier Optics
Holography
Hydrogen Spectrum
Polarized Light and the Fresnel Equations
Nonlinear Optics
Laser Spectroscopy

Modern Physics

Absolute Measurement of the Faraday.
Scanning tunneling microscope.
Gamma ray spectroscopy.
Pulsed nuclear magnetic resonance.
Laser spectroscopy.
Laser trapping and cooling.
Lifetime of muons generated by cosmic rays.

Electronics

Electronic Instruments
DC measurements, dividers, and bridges
Filters and Waveform Shaping
Operational Amplifiers and Negative Feedback
Virtual Ground Amplifiers and magnetic field measurements
Positive Feedback and Oscillators
Transistor Amplifiers
Photometers and lock-in techniques
Digital Logic
Counters and Decoders