

PHYS 431L, Fall 2014

Modern Physics Laboratory

Instructor: Dr. J. Vanderlei Martins **Office:** Physics 429 **Phone:** 410 4552764 **Email:** martins@umbc.edu **Office Hours:** Wednesdays 1:30pm-2:30pm, or just stop by. If I am busy or otherwise unavailable we can arrange for a mutually convenient time to meet.

Course description (from the registrar) Laboratory course intended for physics majors. Purpose is to acquaint the student with some of the phenomena and experimental techniques of atomic and modern physics. Error analysis and advanced data fitting technique are included.

Prerequisites: You must have completed PHYS 324 & PHYS 330L with a grade of C or higher.

Course Objectives

Since this lab is the last experimental course in the curriculum the main objective of this course is to provide an experience closer to a real-life work place or the graduate schools. Unlike the previous laboratory courses you took, in this class we will challenge you by asking you to design and carry out the experiments independently. All the required equipment will be at your disposal in good working order. You will be given a brief outline of the subject as well as supporting material but it will be your own responsibility to design and assemble the experimental set up and decide on the correct data acquisition procedure. Some of the supporting material provided will be write-ups from other universities for similar experiments. There is also a plethora of information available at your fingertips. Therefore it will be of the utmost importance that you come to the lab prepared. The instructor will be there to answer your questions and make sure that you are capable of performing the experiment in a safe and proper manner. As in any lab course, we will place a lot of emphasis on the correct recording and handling of the experimental errors. You will have to include uncertainties for all the measured quantities, and use standard error propagation techniques to find the error associated with the measurements reported in your lab report.

Textbook

You will not need to purchase a textbook for this class.

Course requirements

1. 9 prelabs
2. 9 lab reports
3. Final presentation on an experiment of your choice.

Course grade

- Lab report: 90 points each
 - Prelabs and other assignments: 10 points each
 - Final presentation: 100 points
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- *A = 900 and up*
 - *B = 770 and up*
 - *C = 650 and up*
 - *D = 500 and up*

In principle, everyone can get an A. Total score above 900 guarantees an A. Total score below 500 is an F. I will not grade the class on a curve. This is the absolute grading scale I will use.

Special rule on final grade: At the end of the semester you must have turned in all the reports. If you miss any report (even a single one), you will automatically get a C or F, regardless the grades you got for the other reports.

Class time

Classes are held on Tuesdays 1:00-5:50pm and on Thursdays 1:00-2:15pm in room 208 of the Physics building. We may eventually meet in other rooms for discussions, demonstrations or particular lab experiments.

Lab time

Some experiments will take longer to complete so be prepared to spend Thursday afternoons in the lab in addition to the Tuesday session. I also plan to use the Thursday lab time for demonstrations of the equipment for the upcoming lab work and for going over the theory. We will also meet in the lab on Thursdays.

List of potential experiments

Franck-Hertz effect (FH), Black body radiation (BB), Atomic spectra of hydrogen isotopes (HS), Photoelectric Effect (PE), Muon lifetime (ML), Pulsed NMR (NMR), Hall Effect (HE), Atomic Force Microscope (AFM), Scanning Electron Microscope (SEM), Millikan (MK).

The students will be divided in groups and will rotate between experiments as assigned by the instructor. Other experiments may be alternatively offered during the course

Course policies

Laboratory reports

You are encouraged to work with your partner(s), helping each other to understand the subjects, but you must perform your own analysis and write you own report alone. ***Copying someone else's work is cheating.***

Lab reports are due a week after the experiment was completed. There is no special format for lab reports, but the report should include the following information:

1. Title page (must follow the sample template shown at the end of this syllabus).
2. Introduction (theory, purpose of the experiment)
3. Data and analysis (use graphs and tables whenever possible)
4. Results (again, try to use graphs and tables whenever possible)
5. Conclusions and discussions

Prelabs

To ensure that you will not waste your time by coming to the lab unprepared to do the assigned experiment, you are required to hand in a pre-lab report of no more than 4 pages. In this document you should explain: i) the purpose of this experiment ii) give a brief overview of the theories/principles underlying the experiment iii) give an outline of your experimental approach. More specifically you are expected to explain how you will use the equipment available in the lab, what kind of measurements you will make and what the purpose of these measurements is. Doing a good job on the prelab is important as it will assure that you will be able to use the lab time effectively and it will also provide the basis for your lab report. Before performing the experiment the instructor will discuss your prelab with you to make sure that there are no issues that will compromise your safety and prevent you from completing the work. You are welcome to see your instructor anytime about the experiment, especially the availability of the equipment you may need. The pre lab is due Monday before noon. Your pre-lab should be submitted in PDF format. I will only take PDF files.

For safety reasons, you will be turned away if your instructor believes that you are not prepared to perform the assigned experiment. When this happens, your grade on this experiment will be reduced by 50% automatically (your partner's grade is not affected). You (and possibly your partner) will be allowed to continue on this experiment later during the make-up weeks. ***You do not need to include a cover page for your prelab.***

Late assignments

The assignments must be handed in prior to the beginning of the lab session they are due. **Late assignments are usually not acceptable but in special circumstances, when accepted, the total number of points will be reduced as a function of the delay.**

Oral presentations

Each of you will have to give a 15 min presentation on an experiment you performed during the semester. To avoid repetitive presentations I will assign you a topic based on a preference list you will fill later in the semester. Your presentation will follow the format of a typical research talk given by a scientist in a national conference. I will provide you with an outline later in the semester. The goal of this

assignment is to make you comfortable presenting and answering questions about your work in front of other people. No matter what your job will be in the future you will benefit from being able to present a topic in a clear and concise form.

Exams: This course does not have any additional exams.

Make-up lab policy

Make-up labs will be given only in the event of a documented issue or problem and the instructor must be notified as soon as possible. Having to go out of town on a recreational trip does not constitute a valid reason for requesting a make-up.

Incompletes

Please read carefully the catalog statement on acceptable grounds for an incomplete. The only grounds for obtaining an incomplete in this course is failure to complete all of the last three experiments due to illness. Since, according to the catalog, you must be doing "qualitatively satisfactory" work in order to qualify for an incomplete, you must have at least completed the first six laboratory reports, with a grade of C or better up to the time you took sick. If you are given an "Incomplete", it can be removed by completing the missed assignments (labs and presentation) in the following semester's PHYS 431L course. Note: Do not register for PHYS431L again; just make arrangements with the instructor to attend the appropriate sessions.

Cell phone policy

You must turn off your cell phone during the laboratory time.

Academic Integrity:

You are encouraged to talk to your classmates about assignments. However, each should submit his own original work. The submission of a laboratory report written by someone else or the submission of a laboratory report written by you during a previous semester constitutes cheating. Cheating includes: copying someone else's homework, copying someone else's lab data, altering the lab data in any way.

By enrolling in this course, each student assumes the responsibilities of an active participant in UMBC's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. Cheating, fabrication, plagiarism, and helping others to commit these acts are all forms of academic dishonesty, and they are wrong. Academic misconduct could result in disciplinary action that may include, but is not limited to, suspension or dismissal. To read the full Student Academic Conduct Policy, consult the UMBC Student Handbook, the Faculty Handbook, or the UMBC Policies section of the UMBC Director.

Report Cover Page

[This is the title of your experiment]

by

[your name]

with partner

[your partner's name]

Experiment performed on:

[the date and/or dates you perform the experiment]

Report presented on:

[the date you hand in the report]

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Additional Info

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Lab Notebooks¹

You are required to obtain and use a standard laboratory notebook for this course. The best ones typically have a brown hard-paper cover, and roughly 100 sheets of $\sim 9 \frac{1}{4} \times 11 \frac{3}{4}$ inch graph paper. *The UMBC bookstore sells laboratory notebooks for $\sim \$16$* ; they can also be obtained at many office supply stores.

Laboratory notebooks are an essential part in any experimental research. It's not easy to get in the habit of writing everything down, but it's incredibly worthwhile. You'll learn it first-hand when you sit down a few days later to write up your lab reports. Before leaving each week, I may want to sign-off on your lab notebooks. You should make every effort to record and describe everything you are doing (a good model is to assume you will return to your notebook after 10 years, and then eventually be willing to reproduce, or understand your results!). Write down anything and everything that seems important, including some stuff that doesn't seem so important (personal notes, opinions, ideas, etc.).

Your lab notebook should look more or less like the one pictured in Figure 1, full of notes, numbers, data, and lots and lots of figures. Draw or take pictures of everything! Any printed output, like digital pictures, graphs and tables should be printed and taped in. Notice that lab-notebooks have numbered pages. This eases cross referencing and avoids ripping pages out. And a last advice: don't erase any notes out. Just cross them out. They may be useful sometime.

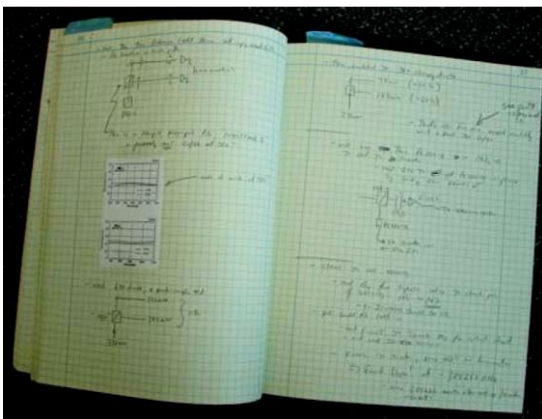


Figure 1. Photograph of a lab notebook. Note that there are lots of figures, data, and plots. Good lab-notebook techniques are an important part of your professional skills!

Safety ²

¹ Adapted from Dr. Todd Pittman, PHYS 330L, UMBC Optics Laboratory

² Adapted from Dr. Todd Pittman, PHYS 330L, UMBC Optics Laboratory

Although we do not anticipate any problems, it is important to realize that we will be working in an active laboratory environment which can always pose certain risks. **Our primary goal is to ensure our safety in the lab.** Some of the equipment relies on high voltages and current and proper precautions must be taken at all times. If you are unsure about the operation of *any equipment or tools*, please ask the instructor or support staff for help. The basic rule is to be over-careful.

Some of our experiments will involve the use of lasers and UV light sources. **No matter how “weak” the source seems to be it can always cause serious damage to the human eye. Never look directly into a laser beam, no matter how many times it has been reflected or how small a laser system is (even a laser pointer). Always wear laser goggles when they are needed. Do not take shortcuts with laser safety.**

For some of our calibrations and experiments we may also use other light sources like integrating spheres, special lamps, fiber illuminators, etc. Never underestimate the potential for eye damage of any light source. Many of these sources are important source of UV radiation and must be properly handled. **Always wear safety goggles as instructed.**

1. When using a laser or an UV source, be sure to turn on the “Laser In Use” sign that hangs outside the lab. This will alert visitors to the fact that a laser is turned on inside the laboratory.
2. Familiarize yourself with the location and contents of the first aid kit. It is mounted on a wall of the lab, and contains bandages, cleansers, etc.
3. The labs are equipped with a master “kill switch”. Familiarize yourself with the location of these switches. They are the big red buttons located just inside the laboratory doors. Pushing this button cuts off all power to the room. Don't worry, they do not shut down the entire building! In the event of an emergency, please use the “kill switch” if appropriate.

Multi-user laboratory work needs some kind of “*good neighborhood code*”.

1. Return all used materials to their original location. Keep the laboratory and specially your working area clean and organized. Return all tools to the tool box after use.
2. If you have to keep some material or instrument leave a note on the material's original location indicating your name, date of removal, and a phone number to contact you; Many laboratories have a “lend book” where you are supposed to make a note of any material taken from the lab.
3. No food, drinks, etc in the laboratory;
4. Try to read the manual BEFORE turning on any unknown equipment;
5. Draw special attention to chemicals, mercury (thermometers), radioactive materials. In case of a spillage, look for knowledgeable help (do not improvise!).
6. Accidents happen. If you break an instrument (for whatever reason) or you find out it is not working properly, leave a note on the instrument indicating clearly what is not working and assure the instrument is directed to maintenance; Much worse than breaking something is not telling anybody!

Error analysis³

Error analysis is a key part of any experimental work. You are expected to perform error analysis for your results. Results should always be stated in forms like, "distance Y is (2.0 ± 0.2) m", rather than "Y about 2 m long". You are expected to discriminate instrumental errors, systematic errors, and statistical errors in all experiments. You may use any method for error propagation, as long as correctly applied. The text *Introduction to Error Analysis*, by John R. Taylor, is available in the Alvin Meckler reading room in the Physics Building.

³ Adapted from Dr. Todd Pittman , PHYS 330L, UMBC Optics Laboratory