

Physics 446 - Advanced Laboratory

Syllabus - Spring 2017

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“In theory, there’s no difference between theory and practice but in practice, there is.”
-Yogi Berra

Required Books:

- *Measurements and their Uncertainties* by Ifan G. Hughes and Thomas P. A. Hase
- A bound lab notebook. (You may use the one you used in Electronics, if you have one.)

Books on 24 hour Reserve at Pickler:

- *Introduction to Error Analysis, 1st Ed.* by John R. Taylor
- *The visual display of quantitative information* by Edward R. Tufte
- *Envisioning Information* by Edward R. Tufte

From the Catalog: Experiments in light, heat, electricity and magnetism, and modern physics. Pre- or co-requisite: PHYS 250.

General Information: This is your first formal exposure at Truman to experimental physics at an advanced level. The experiments you did in your introductory sequence are not as involved as the experiments in this course. Some of you may have taken Electronics, which is a lab class and teaches you about an area of knowledge that is very useful to the experimenter, but it does not teach you experimental *physics*. You may also be exposed to experimental methods during research projects but the exposure is informal and will vary greatly from project to project. The purpose of Advanced Lab is to give you a common background in various aspects of experimental physics. Some of these aspects are:

- experimental design
- data collection, e.g. extracting a signal from noise
- data analysis with uncertainty
- expressing your results in writing
- the use of scientific software

“People who write obscurely are either unskilled in writing or up to mischief.”
-Sir Peter Medawar, “Science and Literature” in *Plato’s Republic* (1984)

This is a writing enhanced course. By the end of the course you will be expected to be able to write near-publication-quality manuscripts. Furthermore, you will be able to do it using L^AT_EX. Regardless of what you do after Truman, learning to write technical documents well will be an important outcome of this course. Judging from comments made by previous students, it is also the part that takes the most time and is the least satisfying *in the beginning*. Many students, however, are pleased, and maybe a bit surprised, by the quality of their writing at the end of the course. Please be aware, however, that good writing is a necessary but not a sufficient condition for success in this course. The quality of your experiments will be a more important factor in achieving a good grade.

This course is also designed to promote a professional attitude in you. Much of the work in this course is self-motivated. You are responsible for working without direct supervision and for meeting course deadlines. I will not explain how to do each lab it is up to you to interpret the pre-lab and perform the experiment. I will, of course, help you to understand and set up the experiment, but only after you have demonstrated due diligence in figuring it out on your own. As preparation for the working world, including graduate school, all work is due when specified. If it is late, it will cost one letter grade per day overdue including Saturday and Sunday. In addition, all labs must be turned in to pass the class. **If you fail to turn in one lab you will fail the class.** (Failing to complete a report can be grounds for termination in the working world.)

Course Structure: The course is divided into a recitation time and a lab time. The recitation time is when formal teaching will occur and probably should be called a lecture period. I will use the recitation time to explain how to use L^AT_EX, Inkscape, and other software, keeping a lab notebook, some basics on writing, etc. We will also work through the book on error analysis. There will be homework associated with the recitation, e.g. problems from the error analysis text, example programs for analyzing or plotting data, etc. Because we are transitioning to a new curriculum, the homework will be based on the backgrounds of the students in the class. If everyone has taken Intermediate Lab, we will be able to do more interesting things. If not, we’ll spend more time on some of the topics covered there.

The lab period is a time reserved for you to work on your experiments and receive help from me. I encourage you to use this time to work on your experiments, but you are also encouraged to work on the experiments outside of the formally scheduled times. You are expected to leave your equipment set up during the two weeks you have to complete an experiment. You may also ask for help from me at times outside the regularly scheduled time, but be aware that I will not always be able to provide it. Also take note that I will be less inclined to ignore my other work to help you if a) you have not been working during the lab time without a good reason (e.g. interference from someone else’s experiment prevents you from working on yours) and b) it is the day before the lab is due and you are still *setting things up*. **You** are responsible for finishing the lab on time.

You will be expected to do five labs, one every two weeks or so, and work through a tutorial on LabVIEW. I will assign the labs and LabVIEW tutorial as the semester progresses.

Experiments: Each experiment has a pre-lab associated with it that describes the general idea behind the experiment and some rough experimental design considerations. You will be required to fill in the theory behind the experiment and flesh out the details of the experimental design. This process will require you to consult outside references including your textbooks from previous classes, library books, journal articles, and the internet. You must cite these references appropriately in your report. I realize the internet is a convenient source but it is not always the most reliable. Additionally, there is information that is more easily obtained from other sources. Try to use some non-internet sources. *Once you understand the theory* and have an experimental design you will then collect and analyze the data. Finally, you will interpret the data in the context of the theory. All of this will be written in two places: your lab report and your lab notebook.

Your lab report is designed to be read by someone unfamiliar with the details of your experiment. Great care must be taken to write clearly and concisely. It is a synthesis of the most relevant aspects and most relevant results of your experiment. Your lab notebook, on the other hand, is a record of all your work in the lab. It should also be clear but is less formal and not as concise. In your notebook you should write everything of importance that you do in lab: ideas for the design, rough sketches of the setup, a neat

drawing of the final design, and, yes, even your data. If you take your data using a computer, you should indicate in your lab notebook where the data is located including the computer identification, e.g. “Ima Student’s laptop”, and the file name. The results of analysis of the data should be taped, pasted, or stapled in your notebook, preferably taped. Likewise any graphs you make using your data should also go into your notebook, even if they are also in your report. In fact, almost everything in your report should have originated in your notebook. It is a good idea to get in the habit of keeping a good notebook now. To encourage this, you will turn in photocopies of your notebook pages when you turn in your lab report. The notebook pages will be graded on completeness and how well they corroborate what is in the report. Note: This does not mean that you should include every little thing from your notebook in your final report. Your lab notebook may have notes on ideas that did not work. There is no need to include such wrong turns in the final report unless something useful can be learned from them. I will discuss these ideas in more detail in class.

Resist the temptation to start setting up your experiment before you read through and understand the theory. There is a good chance that you will only take bad data. You will then have to retake your data. One of the biggest sources of poor performance in this course is not bothering to gain a thorough understanding of the physics of the experiment. The pre-labs alone will not give you that understanding. You must read outside material.

Attendance: I expect you to come to each recitation and the beginning of *each* lab period. After we finish any group business you are free to go about your business. I encourage you to stay and work but I recognize that may not always be possible or desirable. For example, your experiment may be sensitive to vibration and you will get better data at night, when the building is empty. Do not put off working on the lab. It will take longer than you think. Note: While you have a certain amount of freedom in allocating your time you are still obligated to be in class if I deem it necessary. Do not schedule anything else during class time.

Grades: You will be graded as follows:

- first two lab write-ups (6% each)
- second two lab write-ups (14% each)
- your fifth lab write-up (18%)
- your LabVIEW assignment (12%)
- the quality of your lab notebook (15%)
- homework (15%).

Students with Disabilities: I am committed to working with students with disabilities in conjunction with Trumans Office of Disability Services to fulfill any needs of those students, in alignment with the Americans with Disabilities Act (ADA) of 1990. Please let me know early if you have special needs.

Academic Honesty: Obviously, you are to do your own work in this class. In addition, you must learn to properly cite the work of others in your lab reports. It is part of scientific writing to cite the work of authors who have preceded your work in a field and whose work directly influences your work. If you have questions about proper citation please ask me before you turn in the report. Plagiarism is using the work of others and claiming it as your own. Plagiarism will be grounds for disciplinary action that may include expulsion from school. Changing your data is scientific misconduct and will not be tolerated. I will discuss these issues in more depth during class.

Office Hours: Office hours are not the only times I am available for help. My listed office hours just indicate the times I guarantee I will be in or near my office (MG 3172) or my lab (MG 3147). I encourage you to come and ask questions when you need help. If you cannot make it during the regular office hours, then please schedule a time to meet with me. My class schedule is posted on my door and on the web. Please check the web for the latest version.